OCTOBER 1979

ACN 49279

TRAINING INSTRUMENTATION EVALUATION
(TIE)

TECHNICAL REPORT TR 9-79

ADA079134

UNITED STATES ARMY
COMBINED ARMS CENTER

**COMBINED ARMS
COMBAT DEVELOPMENTS ACTIVITY**

DDC

JAN 11 1980

A
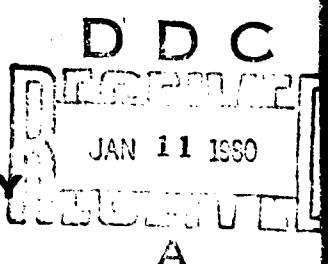
COMBAT OPERATIONS ANALYSIS DIRECTORATE

DDC FILE COPY

80 1 10

M001710

· DIRECTORATE OF COMBAT OPERATIONS ANALYSIS
US ARMY COMBINED ARMS COMBAT DEVELOPMENT ACTIVITY

TRAINING INSTRUMENTATION EVALUATION
(TIE)

by

CPT Robert A. Martray

Dr. Michael R. Anderson

ACN 49279

Approved by:
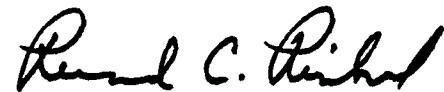
RICHARD C. RINKEL
Chief, Analysis Division

LELAND C. PLEGER
Deputy Director

ROBERT T. REED
Colonel, Armor
Director
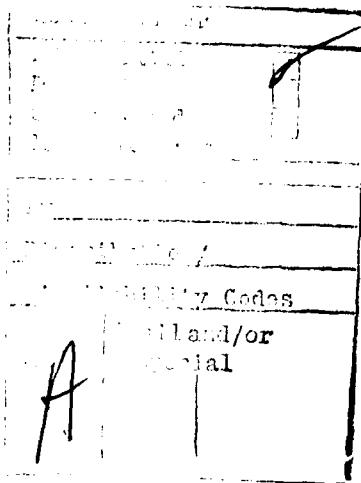
REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER . . . . Technical Report TR 9-79	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Training Instrumentation Evaluation (TIE)		5. TYPE OF REPORT & PERIOD COVERED Final reptis 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Robert A. /Martray Michael R. /Anderson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Combined Arms Combat Developments Activity Combat Operations Analysis Directorate, ATZLCA-CAA-T Fort Leavenworth, KS 66027		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS ACN 49279
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Combined Arms Training Developments Activity ATTN: ATZL-TDA-AD Fort Leavenworth, KS 66027		12. REPORT DATE Oct 79 13. NUMBER OF PAGES 99
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) CACDA-TR-9-79		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Ground Combat Simulation; Tactical Engagement Simulation Training; National Training Center; Tactical Proficiency; Unit Proficiency; IFCAS

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Training Instrumentation Evaluation (TIE) was a tank heavy company team field test designed to provide baseline information on training via tactical engagement simulation in an instrumented environment. The test results are being used as an aid in the planning of a National Training Center (NTC) for armor and mechanized infantry battalions. The United States Army Combat Developments Experimentation Command (CDEC) conducted the test and authored the test report.

This paper describes the data reduction/analysis performed on the TIE test data

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

408 082

by the Directorate of Combat Operations Analysis, US Army Combined Arms Combat Development Activity. This analysis was limited to providing insights into changes in unit tactical proficiency that occurred when instrumented tactical engagement simulation was used for training; and to verify provisional measures of effectiveness. The data analysis results were provided as input to the TRADOC/FORSCOM NTC development effort.

FOREWORD

This analysis was conducted by the Test Design and Analysis Branch of the Combat Operations Analysis Directorate, US Army Combined Arms Combat Developments Activity, in support of the US Army Combined Arms Training Development Activity directed Training Instrumentation Evaluation (TIE). Authority for this experiment and analysis is contained in the Outline Test Plan, Training Instrumentation Evaluation (TIE) Test, FC 095, 28 March 1978. This technical paper was completed in October 1979.

The authors wish to express their appreciation to Miss Sue Wright and Mr. Jack Low for developing graphic portrayals of the TIE trials at the Combat Operations Analysis Directorate's Central Graphics Facility. Without their involvement several of the reported insights would have been overlooked.

ABSTRACT

The Training Instrumentation Evaluation (TIE) was a tank heavy company team field test designed to provide baseline information on training via tactical engagement simulation in an instrumented environment. The test results are being used as an aid in the planning of a National Training Center (NTC) for armor and mechanized infantry battalions. The United States Army Combat Developments Experimentation Command (CDEC) conducted the test and authored the test report.

This paper describes the data reduction/analysis performed on the TIE test data by the Directorate of Combat Operations Analysis, US Army Combined Arms Combat Development Activity. This analysis was limited to providing insights into changes in unit tactical proficiency that occurred when instrumented tactical engagement simulation was used for training and to verifying provisional measures of effectiveness. The data analysis results were provided as input to the TRADOC/FORSCOM NTC development effort.

EXECUTIVE SUMMARY

1. BACKGROUND.

a. The United States Army Training and Doctrine Command (TRADOC) and the United States Army Forces Command (FORSCOM) Headquarters are working to develop a National Training Center (NTC), which will train armor and mechanized infantry battalions. This concept calls for battalions to rotate through the NTC for approximately 2 weeks of intensive combined arms training. The units will participate in both live fire and engagement simulation exercises against a realistic threat force using tactical air, artillery, and electronic warfare. The NTC will be designed to provide training exceeding the scope possible at a unit's home station.

b. A basic premise of the NTC concept asserts that a unit learns not only from participating in live fire and engagement simulation exercises but also from After Action Reviews (AARs) that follow the training exercises. This premise further states that the AARs can be most effective when they are based on detailed data collected during the conduct of the training exercises.

c. In September 1977, TRADOC Headquarters expressed a desire to collect data during the Tanks and Mechanized Infantry (TAMI) experiment to assist in the development of the NTC. When TAMI was cancelled, the effort shifted to developing a separate test to support the NTC. This test was scheduled at Fort Hunter Liggett, California for January and February of 1978. Heavy rainfall in January and February along with conflicting FORSCOM commitments caused the test to be delayed until July-September 1978.

d. TRADOC designated the Combined Arms Training Development Activity (CATRADA) as the test proponent. The basic concepts of the project analysis were developed at a 2-day planning conference held 16-17 November 1977 with representatives from TRADOC, CATRADA, the Army Training Study (ARTS), the Army Research Institute for Behavioral and Social Sciences (ARI), and the Army Combat Developments Experimentation Command (CDEC). Conferees agreed that the Training Instrumentation Evaluation (TIE) test would be conducted within the following context.

(1) It would be the first of a series of tests designed to quantify the increase in tactical proficiency that could be achieved by providing detailed objective feedback to units participating in two-sided, instrumented engagement simulation exercises. This company level test would focus on the incremental benefits of training at an NTC after the test units had completed a Multiple Integrated Laser Engagement System (MILES) type of training at home station. As the initial test, TIE would attempt to identify general trends and develop techniques and methodology for subsequent tests.

(2) The experience gained during this test would be used to facilitate the progressive development of quantifiable measures of unit effectiveness. It would also provide insights into the control structure necessary to conduct instrumented training exercises at the NTC.

(3) The data collection effort would focus on the time and position location of significant tactical events, the recording of voice transmissions (VRS) on the company command net, video recordings of significant events, and any data that might be used to provide subjective support for the After Action Reviews (AARs).

2. PURPOSE. The purpose of the TIE test was to provide data at the company/team level which could be used to assist in the development and evaluation of tactical engagement simulation training with instrumented feedback as part of the concept for a National Training Center.

3. OBJECTIVES.

   a. TIE objectives addressed in this report are as follows:

   (1) Objective 1. Provide insights into changes in the level of unit tactical proficiency that occur when instrumented tactical engagement simulation is used for training.

   (2) Objective 2. Verify or revise provisional measures of effectiveness (MOE).

   b. The following additional objectives are addressed in USACDEC report, Training Instrumentation Evaluation (TIE) Final Report dated December 1978.

   (1) Objective 3. Gain insights into the nature and extent of information required to provide the feedback and diagnostic information required to improve tactical proficiency.

   (2) Objective 4. Provide information to assist in the development of a MILES control system and ultimately that for a National Training Center.

4. SCOPE.

   a. TIE was a two sided force-on-force instrumented training exercise that matched a US tank heavy company team in a movement to contact/hasty attack scenario against a reinforced motorized rifle platoon in a hasty defense. The opposing force was structured to provide a Red to Blue force ratio of 1:3. It provided for integration of ATGMs (i.e., TOW , DRAGON and SAGGER); the primary weapon system on the M113 (50 Cal MG); the

primary and secondary weapons on M60 tanks (105mm and 7.62mm coax MG, respectively); and the 73mm antitank gun (SPG-9). Appropriate US weapon systems were used as surrogates to represent the threat weapons. Infantry small arms (M16A1) were instrumented in a "stand alone" mode (i.e., not interfaced with main computer system). Indirect artillery fires could be requested by the players, and casualty assessments were made via the Indirect Fire Casualty Assessment and Suppression (IFCAS) system. Although ammunition depletion was portrayed during TIE, there was no means of portraying logistics or resupply requirements.

b. All trials were conducted in the Gabilan Valley at Fort Hunter Ligget, CA. To minimize the effects of terrain familiarity, specific trial sites were varied.

c. The experiment was conducted with two US force player sets and one threat force. Player set 1 executed 14 trials over a 2-week period of time. Player set 2 executed 8 trials over a 2-week period against the same threat force.

d. The test design of TIE was atypical; that is, the TIE test was not structured as an ordered number of design cells, defined by specific independent variables, containing a specific number of trials, and intended to be compared statistically against one or more of the other cells. Instead, the test consisted of two sequences of trials performed by separate player groups. Fourteen trials were executed by player group 1 and comprised the first sequence; 8 trials were conducted by player group 2 and comprised the second sequence. Each sequence was considered as an ordered series of learning experiences during which the player set was expected to improve its tactical proficiency. Each sequence was used to roughly plot the learning effect for that unit over that particular player set and the order of learning experiences. In order to establish a rough estimate of the relative proficiency of the two units, selected trials were conducted under identical conditions with no player feedback. For consistency, the same defensive player set was used to oppose the two offensive player sets. Numerous trial sites were used, and within each trial sequence the defensive posture was not duplicated on the same site.

5. ANALYSIS RESULTS.

a. The TIE analysis indicated that the level of tactical proficiency for player group 2 increased during a series of instrumented engagement simulation exercises. The observation that this trend was not apparent for player group 1 can be attributed to some unforeseen fluctuations in the group 1 situation. For example, the effective force ratio was varied in the early trials due to instrumentation difficulties while at the same time a major modification in defensive tactics was occurring. Further analysis of TIE data indicated player group 1 improved in specific functional areas during their sequence of instrumented engagement simulation training exercises.

b. Quantitative measures of effectiveness that were most indicative of tactical proficiency were:

o Total number of threat antitank weapon systems killed

o Total number of threat antitank weapon systems killed or surviving with ammunition depleted

o Relative survivability

o Percent of OPFOR weapons paired by US forces

o Effective (US/OPFOR) force ratio (includes only those weapon systems that effectively paired enemy elements)

o Percent of US AT firings resulting in pairings

o OPFOR weapon casualties per US AT round fired

o AT weapon effective exchange ratio (EER)

o Casualty exchange ratio (CER)

c. Quantitative measures of effectiveness that were most indicative of learning occurring in one or more functional areas during the trial sequence were:

o Number of threat AT weapon systems killed

o Number of threat weapons not paired by US weapons

o Mean number of US weapons pairing each threat element

o Number of M60s and TOWs pairing at least once

o Percent of Blue AT firings resulting in effective pairing

o Blue/Red effective pairings

o Percent of threat targets effectively paired

o Percent of Blue force effectively employed

o Effective (Blue/Red) force ratio (EFR)

6. SUMMARY/CONCLUSIONS.

a. The available data indicated that there was a considerable degree of variance among the evaluators' ratings of tactical proficiency.

Included among the factors possibly contributing to this variance are:

    (1) The evaluators had varying degrees of background and
experience (e.g., company grade and field grade officers, different levels
of military schooling (basic, advanced courses, CGSC), etc.).

    (2) The evaluators observed the trials from different vantage
points (OPs, helicopters, positions in the battle area, etc.).

    b. The averages of the evaluators' ratings from the Test Directorate
Opinion Questionnaires (TDOQ) were shown to be consistent to the averages
of the evaluators' ratings from the Controller Daily Performance Records
(CDPR) both in overall proficiency and across most functional areas. This
supports the validity of using the proficiency rankings in analyzing the
MOEs. It is also indicative that the individual evaluator observations,
used to determine the ratings, were consistent with task analyses derived
from the ARTEP.

    c. The TIE analysis indicates that the level of tactical proficiency
for player group 2 increased during a series of instrumented engagement
simulation training exercises. The observation that this trend was not
apparent for player group 1 can be attributed to several confounding
effects.

    d. The learning accomplished during a sequence of force-on-force
instrumented exercises is greatly obscured by the trial-to-trial variance
inherent in such exercises.

    e. The large number of unpaired firings during force-on-force
instrumented exercises poses a significant problem in measuring mean
assessment/kill ranges.

    f. The engagement simulation force-on-force training environment
provides quantifiable MOE related to areas of tactical operations that
have heretofore been evaluated subjectively.

TABLE OF CONTENTS

Technical Report TR 9-79

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Concl)

1. INTRODUCTION.

a. General.

(1) The United States Army Training and Doctrine Command (TRADOC) and the United States Army Forces Command (FORSCOM) Headquarters are working to develop a National Training Center (NTC), which will train armor and mechanized infantry battalions. This concept calls for battalions to rotate through the NTC for approximately 2 weeks of intensive combined arms training. The units will participate in both live fire and engagement simulation exercises against a realistic threat force using tactical air, artillery, and electronic warfare. The NTC will be designed to provide training exceeding the scope possible at a unit's home station.

(2) A basic premise of the NTC concept asserts that a unit learns not only from participating in live fire and engagement simulation exercises but also from After Action Reviews (AARs) that follow the training exercises. This premise further states that the AARs can be most effective when they are based on detailed data collected during the training exercises.

b. Background.

(1) In September 1977, TRADOC Headquarters expressed a desire to collect data during the Tanks and Mechanized Infantry (TAMI) experiment to assist in the development of the NTC. When TAMI was cancelled, the effort shifted to developing a separate test to support the NTC. This test was scheduled at Fort Hunter Liggett, California for January and February of 1978. Heavy rainfall in January and February along with conflicting FORSCOM commitments caused the test to be delayed until July through September of 1978.

(2) TRADOC designated the Combined Arms Training Development Activity (CATRADA) as the test proponent. The basic concepts of the project analysis were developed at a 2-day planning conference held 16-17 November 1977 with representatives from TRADOC, CATRADA, the Army Training Study (ARTS), the Army Research Institute for Behavioral and Social Sciences (ARI), and the Army Combat Developments Experimentation Command (CDEC). Conferees agreed that the Training Instrumentation Evaluation (TIE) test would be conducted within the following context.

(a) It would be the first of a series of tests designed to quantify the increase in tactical proficiency that could be achieved by providing detailed objective feedback to units participating in two-sided, instrumented engagement simulation exercises. This company level test would focus on the incremental benefits of training at an NTC after the test units had completed a Multiple Integrated Laser Engagement System (MILES) type of training at home station. As the initial test, TIE would

1

attempt to identify general trends and develop techniques and methodology for subsequent tests.

(b) The experience gained during this test would be used to facilitate the progressive development of quantifiable measures of unit effectiveness. It would also provide insights into the control structure necessary to conduct instrumented training exercises at the NTC.

(c) The data collection effort would focus on the time and position location of significant tactical events, the recording of voice transmissions (VRS) on the company command net, video recordings of significant events, and any data that might be used to provide subjective support for the After Action Reviews (AARs).

c. Purpose. The purpose of the TIE test was to provide data at the company/team level that could be used to assist in the development and evaluation of tactical engagement simulation training with instrumented feedback as part of the concept for a National Training Center.

d. Objectives.

(1) TIE objectives addressed in this report are as follows:

(a) Objective 1. Provide insights into changes in the level of unit tactical proficiency that occur when instrumented tactical engagement simulation is used for training.

(b) Objective 2. Verify or revise provisional measures of effectiveness (MOE).

(2) The following additional objectives are addressed in USACDEC report, Training Instrumentation Evaluation (TIE) Final Report dated December 1978 (Ref 1).

(a) Objective 3. Gain insights into the nature and extent of information required to provide the feedback and diagnostic information required to improve tactical proficiency.

(b) Objective 4. Provide information to assist in the development of a MILES control system and ultimately that for a National Training Center.

e. Essential Elements of Analysis (EEA). The essential elements of analysis addressed in this report are outlined below, and the objective to which each relates is indicated.

(1) EEA 1. Was there substantial agreement among the evaluators in rating the level of tactical proficiency of the US forces? (OBJECTIVE 1)

2

(2) EEA 2. What was the rank-ordered hierarchy of unit tactical proficiency as determined from the evaluators' average ratings of tactical proficiency? (OBJECTIVE 1)

(3) EEA 3. How does the level of tactical proficiency change after a series of instrumented engagement simulation training exercises? (OBJECTIVE 1)

(4) EEA 4. What MOEs were most indicative of the ratings of unit tactical proficiency? (OBJECTIVE 2)

(5) EEA 5. What MOEs were indicative of learning occurring in a particular area over trial replications? (OBJECTIVE 2)

(6) EEA 6. What insights can be gained concerning the validity of the MOEs as they were measured during TIE? (OBJECTIVE 2)

(7) EEA 7. What insights can be gained from the TIE data regarding the overall MOE structure? (OBJECTIVE 2).

f. Scope. TIE was a two sided force-on-force instrumented training exercise that matched a US tank heavy company team in a movement to contact/hasty attack scenario against a reinforced motorized rifle platoon in a hasty defense. It provided for integration of ATGMs (i.e., TOW, DRAGON, and SAGGER); the primary weapon system on the M113 (50 Cal MG); the primary and secondary weapons on M60 tanks (105mm and 7.62mm coax MG, respectively); and the 73mm antitank gun (SPG-9). Appropriate US weapon systems were used as surrogates to represent the threat weapons. Infantry small arms (M16A1) were instrumented in a "stand alone" mode (i.e., not interfaced with main computer system). Indirect artillery fires could be requested by the players, and casualty assessments were made via the Indirect Fire Casualty Assessment and Suppression (IFCAS) system. Although ammunition depletion was portrayed during TIE, there was no means of portraying logistics or resupply requirements.

g. Test Concept.

(1) The test design of TIE was atypical; that is, the TIE test was not structured as an ordered number of design cells, defined by specific independent variables, containing a specific number of trials, and intended to be compared statistically against one or more of the other cells. Instead, the test consisted of two sequences of trials performed by separate player groups. Trials 1-14 were executed by player group 1 and composed the first sequence; trials 15-22 were conducted by player group 2 and composed the second sequence. (Trials 1-14 and 15-22 were designated as 101-114 and 201-208 respectively, to distinguish a set of trial replications for each player group.) Each sequence was considered as an ordered series of learning experiences during which the player set

3

was expected to improve its tactical proficiency. Each sequence was used to roughly plot the learning effect for that unit over that particular player set and the order of learning experiences. In order to establish a rough estimate of the relative proficiency of the two units, selected trials were conducted under identical conditions with no player feedback. For consistency, the same defensive player set was used to oppose the two offensive player sets. Numerous trial sites were used; and within each trial sequence, the defensive posture was not duplicated on the same site. The order in which sites and defensive postures appeared for the first player set was generally repeated for the second player set.

(2) The post-trial feedback sequence for the first player set consisted of two trials with no AARs followed by six trials with AARs using only information that had been manually collected by controllers. The last six trials had full AARs developed from controller and instrumentation collected data. The first two trials were used to make a subjective evaluation of the initial level of unit tactical proficiency for comparison with the second player set. The next six trials provided for a measure of the learning from engagement without instrumented feedback. Even though feedback was controlled following this procedure, all trials were instrumented and thus provided a measure of learning in an instrumented environment. This entire sequence for the first player set was used as a developmental period in which AAR and controller techniques were refined and practiced.

(3) The post-trial feedback sequence for the second player set consisted of two trials with no feedback to establish the level of tactical proficiency relative to the first player set, followed by six trials using the refined AAR techniques developed with the first player set. Controller and instrumentation feedback were combined and used in the AARs for this set. The last two trials included the use of smoke by the attacking force.

h. Trial Description.

(1) Trials began on 4 August 1978 and continued through 14 September 1978. Table 1 depicts the trial schedule. Each trial lasted approximately 2 hours.

(2) The test was conducted in the Gabilan Valley area of Fort Hunter Liggett (FHL) - Map Stock No. V795SHUNTER101. Within this area, threat platoon positions were selected and occupied, and the company team was given boundaries within which to conduct a movement to contact maneuver. The valley is approximately 3 to 4 kilometers in width and 5 kilometers in length. Terrain is basically gently rolling, broken by medium to deep ravines and scattered high hills.

(3) The test scenario was designed to create a realistic tactical environment for a company team. A synopsis of the actual scenario is given below.

4

Table 1. Trial Schedule

Player Group 1				Player Group 2		
Trial	Date	Day		Trial	Date	Day
101	4 Aug	Friday				
102	7 Aug	Monday		201	31 Aug	Thursday
103	8 Aug	Tuesday		202	1 Sept	Friday
104	9 Aug	Wednesday				
105	10 Aug	Thursday		203	5 Sept	Tuesday
106	11 Aug	Friday				
				204	7 Sept	Thursday
107	15 Aug	Tuesday				
108	16 Aug	Wednesday		205	11 Sept	Monday
109	17 Aug	Thursday		206	12 Sept	Tuesday
110	18 Aug	Friday		207	13 Sept	Wednesday
111	21 Aug	Monday		208	14 Sept	Thursday
112	22 Aug	Tuesday				
113	23 Aug	Wednesday				
114	24 Aug	Thursday				

5

(a) A threat reinforced motorized rifle platoon was advancing as a part of the lead company of a motorized rifle battalion in the attack. The lack of success of the threat main effort forced a halt. The threat platoon occupied a hasty defense pending orders to advance or to occupy a deliberate defense. The threat platoon, with dismounted antitank (AT) support from battalion, was portrayed as operating at slightly reduced strength due to the US covering force action but had received some resupply of ammunition. If attacked, the platoon was to defend in place until reinforced or ordered to withdraw.

(b) On the US side, the covering force had just completed its hand-off of the battle to the units occupying the main battle area. To take advantage of the lack of enemy success in his main effort, these US forces not opposed by the main effort were ordered to attack. The company team, which was occupying a battle position in the main battle area, was designated as the lead element for a task force that was to attack as part of the division's secondary effort. Intelligence available to the company team commander indicated that enemy forces of about company strength or less had occupied a position to his front. Due to the nature of the enemy's unexpected halt and the recent passage of the covering force, the disposition of the enemy forces was unknown. Although short two tanks per platoon, the company team's supply situation was good. All team weapons and supporting artillery had a full basic load on hand. The company was ordered to move to the high ground to its front and to be prepared either to establish an overwatch position for the rest of the task force or to continue the attack, depending on the situation. If enemy contact was made, the company was to develop the situation and continue the advance, if possible. Authority to bypass enemy locations was retained by the battalion commander. Contact with the enemy was likely.

(4) The US force consisted of a tank heavy company team reinforced by additional AT weapons and supported by indirect fire weapons. The US force structure is shown in figure 1. All indirect fires were simulated. Two identically organized player sets were used. To the greatest extent possible, tactical free play was used during each trial. The team commander was not allowed to bypass any element unless permission was granted by Test Directorate personnel representing the battalion headquarters. Here, the intention was to encourage the employment of the infantry elements so that their learning could be observed.

(5) The threat force consisted of elements of a motorized rifle company reinforced with tanks and battalion AT weapons and supported by indirect fire. The threat force structure with a summary of player personnel and weapons played is shown in figure 2. Indirect fire weapons were simulated. For test control, the tank platoon leader commanded the entire threat force. Current Soviet doctrine for the employment of forces and conduct of the hasty defense was followed. Threat force actions were designed to realistically develop the action against the attacking US

6

155mm (Simulated)

4.2 in Mortar (Simulated)

DS

DS
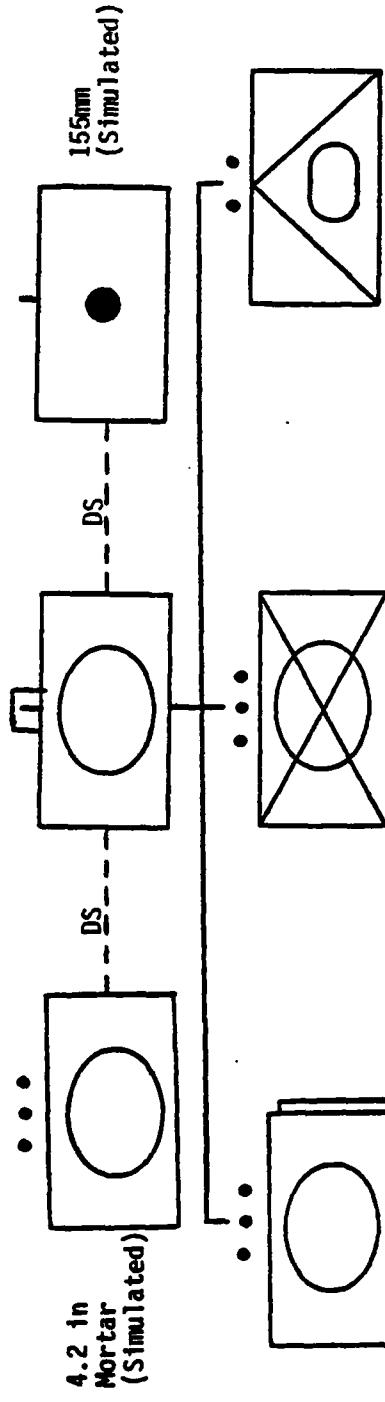
WEAPON SUMMARY

3 (6) M60 Tanks

4 M113 w/50 Cal MG
23 M16A1
1 DRAGON[a]

2 M113/TOW

PLAYER PERSONNEL SUMMARY

1 Company Commander
1 Driver
1 Gunner

1 Platoon leader[b]
1 Platoon sergeant[b]
1 RATELO[b]
3 Squad leaders[b]
4 Drivers
4 Gunners
17 Riflemen[b]
1 DRAGON Gunner

1 (2) Platoon leaders
1 (2) Platoon sergeants
1 (2) Tank commanders
3 (6) Drivers
3 (6) Gunners

2 Squad leaders
2 Drivers
2 Leaders

a. DRAGON was given 3 lives to represent 1 DRAGON per squad
b. Infantry Direct Fire Simulator (Stand-Alone)

Figure 1. Blue force structure.

7

122mm
(Simulated)

DS

a

WEAPON SUMMARY

2 BMP/SAGGER (M113/TOW)   9 AKM (M16)   1 SPG-9 (TOW)   2 T-62 Tank (M60)
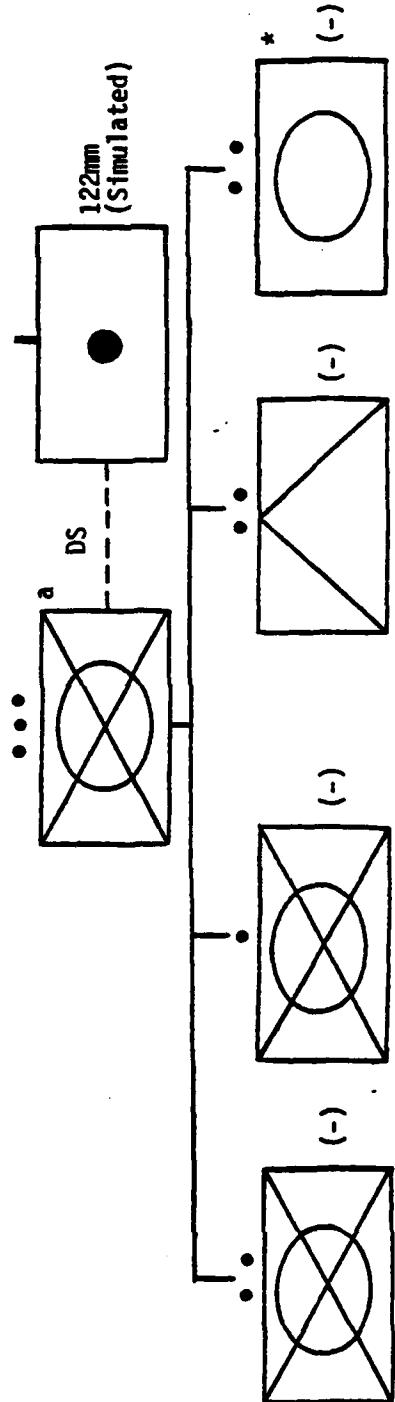
PLAYER PERSONNEL SUMMARY

2 Squad leaders	1 Squad leader[b]	1 Gunner	1 Platoon leader
2 Drivers	8 Riflemen[b]		1 Tank commander
2 Gunners			2 Drivers
			2 Gunners

a. Command and control was through the armor platoon leader
b. Infantry Direct Fire Simulator (stand-alone)
( ) Indicates surrogate used

Figure 2. Threat force structure.

8

force. The defensive play was free during the conduct of trials except when controller personnel interjected specific rules of engagement to force tactical situations of interest.

i. Instrumentation/Data Collection. Data requirements to support the provisional list of MOEs were identified prior to TIE and were incorporated into the data collection process at CDEC. Position location and fire/hit/kill event data were transferred to the United States Army Combined Arms Combat Development Activity (CACDA) on computer tapes.

(1) Objective data were collected by the CDEC instrumentation system as follows:

(a) The Multi-Computer System (MCS) provided control and interface for other systems, automatic data recording, and casualty assessment/kill event data.

(b) The Range Measuring System (RMS) provided continuous location data (10-digit coordinates) of each instrumented system (tank, antitank guns, ATGM, and APC).

(c) The Direct Fire Simulator (DFS - figure 3) provided fire/hit event data (firer and target identification, location, type ammunition expended, target posture, time of firing, etc.). Only tanks, ATGMs, APCs, and the SPG-9 antitank gun were instrumented with DFS. No information concerning the target of a firing was available unless a hit was scored.

(d) The Infantry Direct Fire Simulator (IDFS) provided fire/hit/kill event data to infantrymen in a stand-alone mode (not automatically recorded by interface with MCS).

(e) The Indirect Fire Casualty Assessment and Suppression (IFCAS) System provided casualty assessment resulting from indirect fire and a limited amount of artillery impact cuing on the battlefield.

(f) The Voice Recording System (VRS) provided time-tagged voice recordings of tactical radio traffic.

(g) The Photographic Instrumentation and Data Recording System (PIDRS) provided time-tagged black and white video recordings of critical events.

(2) Subjective data and/or chronological listing of significant events were manually recorded on evaluator forms during the exercise by TIE evaluators. Evaluators were assigned to each platoon, the TOW section, and the FO of the US company/team.

9
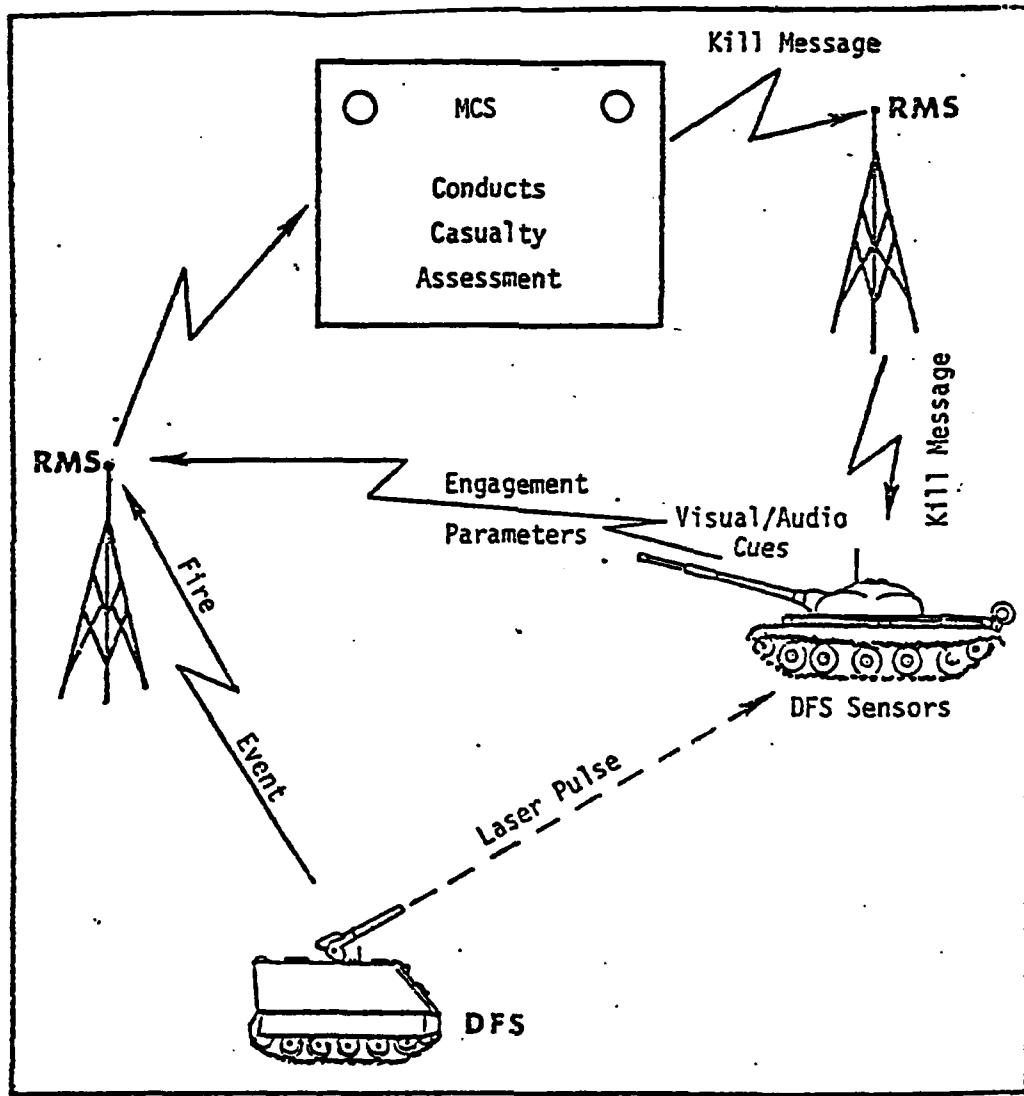
Figure 3. The basic direct fire engagement.

2. METHODOLOGY.

    a. Data Base.

        (1) While all trials of the second player set yielded useful
data, only 10 of the 14 trials conducted in the first player set were
usable. Due to instrumentation problems, data from trials 101 and 104
were determined to be invalid. Trials 102 and 103 were valid for data
collection, but the test conditions were inconsistent with the remaining
trials. It was feared a significant bias in the data could occur from
these trials, and they were dropped from the analysis. Inconsistencies
within the test conditions included:

        (a) The Effective Force Ratio (EFR), which was designed to
be a constant, was disrupted by instrumentation difficulties in the early
trials. Though all the threat systems shown in figure 2 were present in
all exercises and could draw fire and be killed, only those listed below
were capable of causing casualties and were fully effective:

        . Trial 101: SPG-9

        . Trial 102: 2 each T-62s

        . Trial 103: 2 each T-62s, 1 each SPG-9

        . Trial 104: 2 each T-62s, 1 each SPG-9

        . Trial 105: 2 each T-62s, 2 each BMP/SAGGERS,
                      1 each SPG-9

        . The full complement of effective OPFOR weapons was available in
          all remaining trials.

This instrumentation problem resulted in an EFR (Blue/Red) of 7:1 for
trial 102 and 4.7:1 for trial 103 as compared to 2.8:1 for the rest of the
trials. The antitank EFR (Blue/Red) was 5:1 for trial 102 and 3.3:1 for
trail 103 as opposed to 2:1 for the remaining trials. Also, the OPFOR had
no long range antitank capability for trials 102 and 103. During each of
these trials the BMP/SAGGERs were destroyed by the US forces after they
had attempted to engage targets.

        (b) In trial 102 the defensive weapon positions employed by
the OPFOR were established in a relatively small area. Starting with
trial 103 and continuing throughout the remaining trials, the defense was
opened up to accommodate the greatest part of the avenue of approach
(figure 4 provides a graphical comparison of the OPFOR weapon locations in
a closed versus an open defense). Thus, the OPFOR was modifying and
refining the defensive tactics while encountering an EFR that was more
than double what it would be during the remaining trials.

11
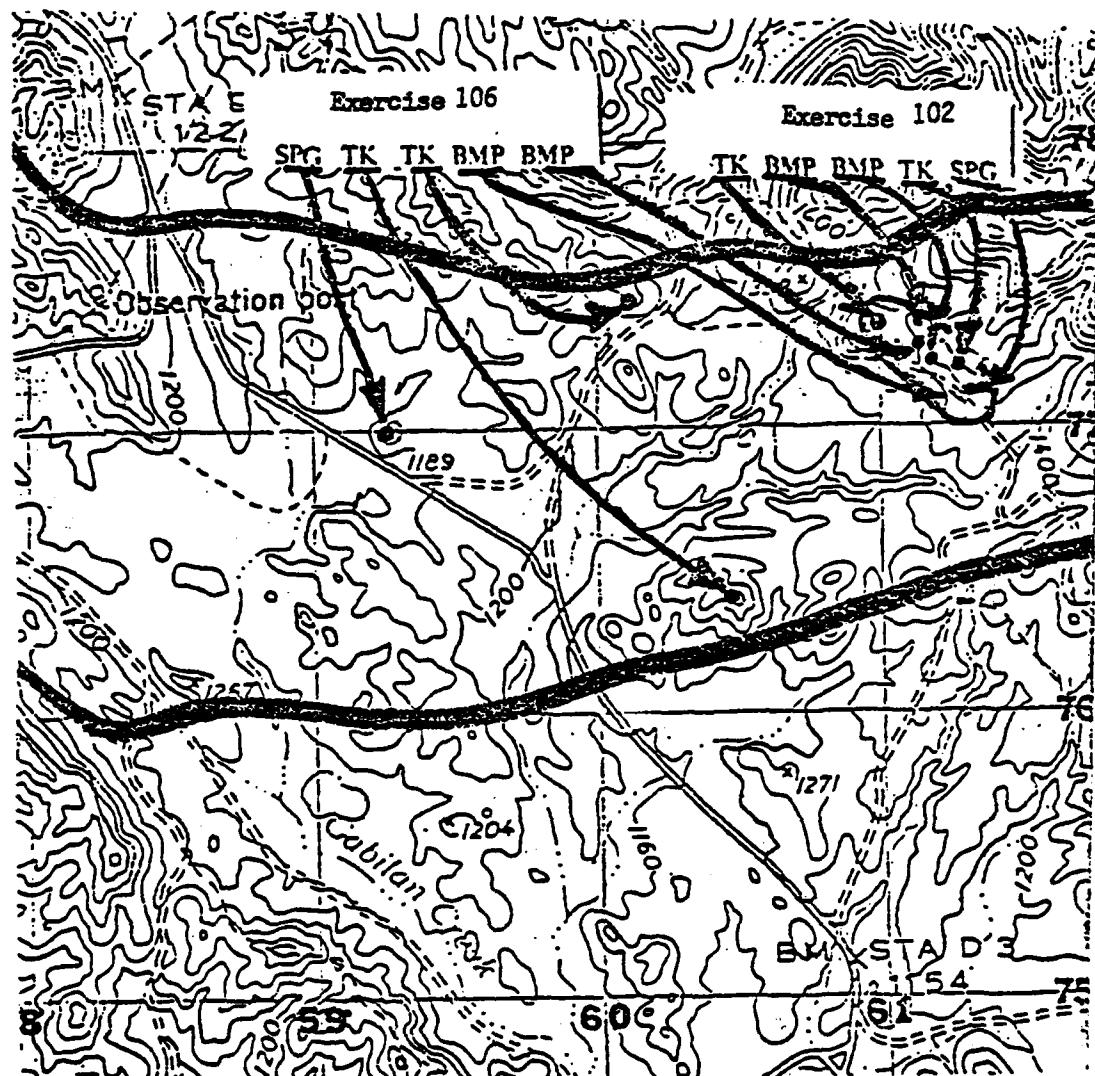
Figure 4. Approximate lane boundaries and defensive weapons positions in trials 102 and 106.

(2) The primary analysis effort was concentrated on the output from the sequence of trials conducted by the second player set. Data from the first player set trial sequence were used to verify and support findings resulting from this primary analysis effort. Justification to concentrate on player set 2 includes the following rationale.

(a) More supplemental data were available for player set 2 including:

. Video recordings of key events

. Controller daily performance records based on ARTEP type tasks recorded by platoon/section evaluators

(b) The entire sequence for the first player set was used as a developmental period in which After Action Review (AAR) and controller techniques, as well as defensive OPFOR tactics, were refined and practiced. Any of the following factors might have introduced a considerable bias:

. Learning process of the OPFOR.

. Learning process of the controllers/evaluators.

. Changes and modifications made to the AAR (e.g., AARs with and without feedback provided by instrumentation, ascending chain of command, descending chain of command, and seminar type AARs were evaluated in the first sequence).

(c) More evaluators were available during player set 2 to rate the overall unit proficiency. Based on this increase in evaluations a more reliable mean rating of the each unit's proficiency was expected for each trial.

(d) The results of the second sequence of trials were expected to be more reliable and valid since the test conditions were more tightly controlled. Figure 5 is a schematic representation of the relationship between the variables in effect and the trials of player set 2. Figure 6 depicts the OPFOR defensive area of operations.

13
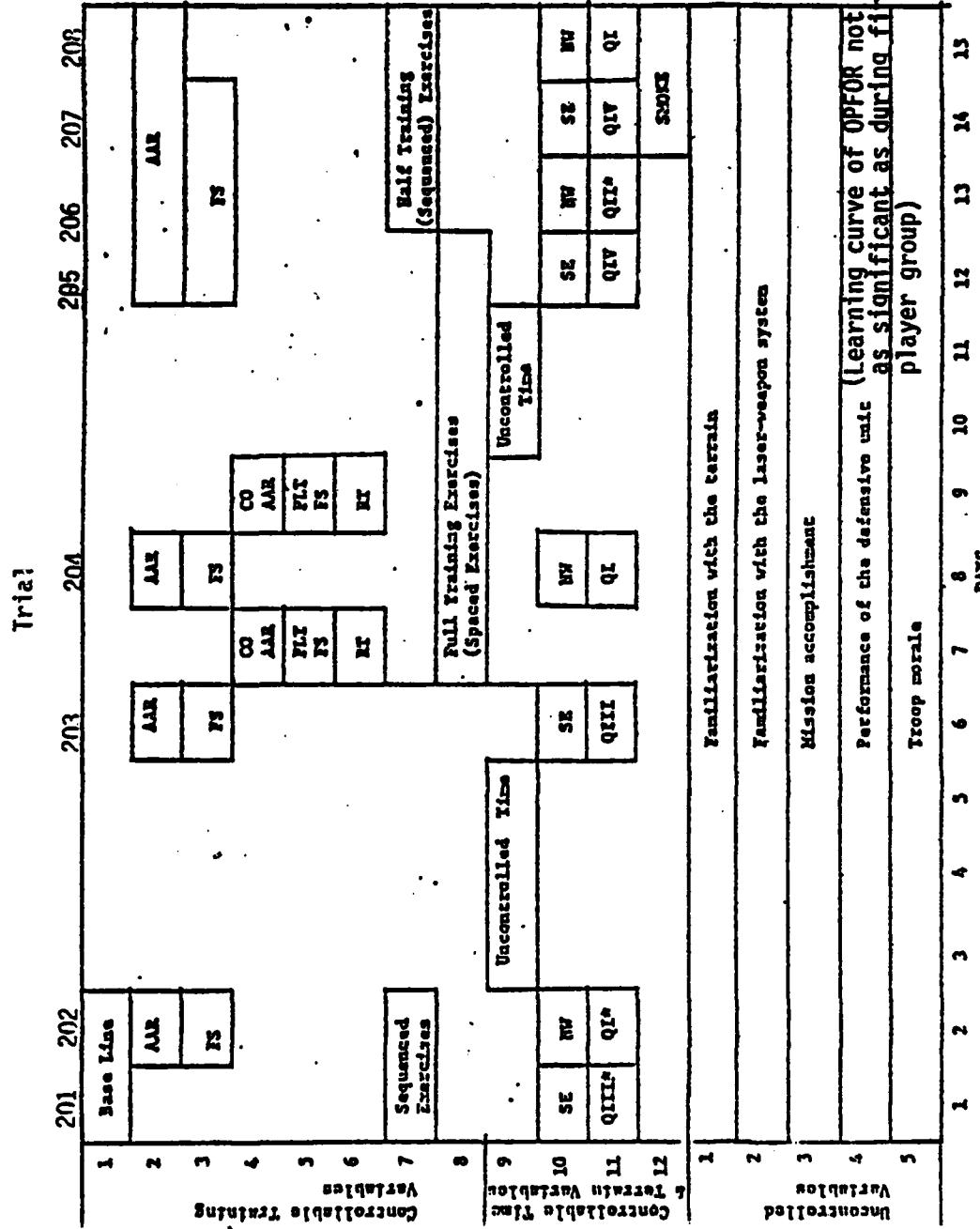
Figure 5. Relationship between the variables in effect during TIE and trials 201 through 208.

NOTE: Asterisk in variable 11 represents previously unused terrain. After Action Review (AAR), Feedback Session (FS), Remedial Training (RT), Quadrant (Q).

14
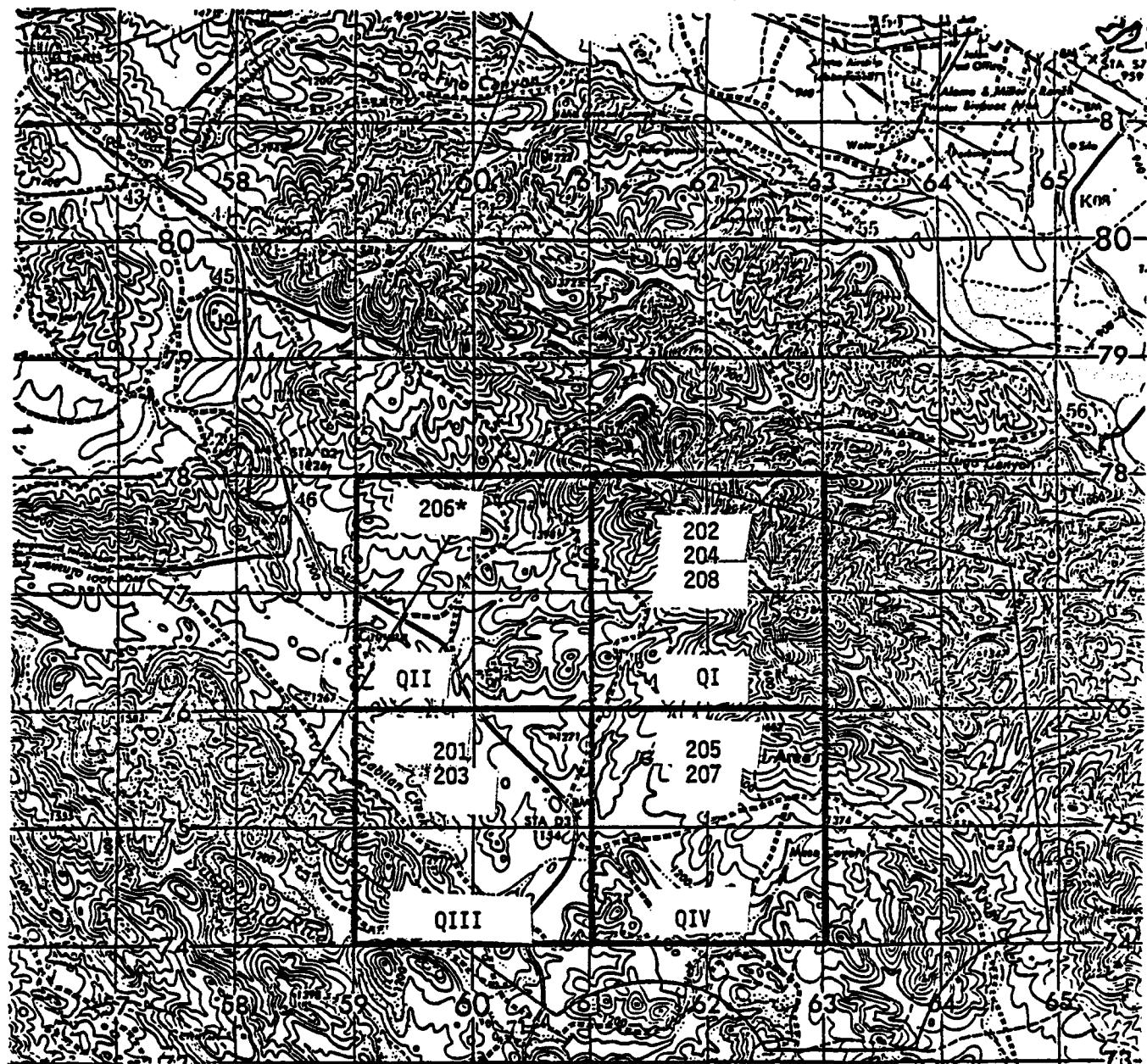
Figure 6. Schematic diagram of OPFOR defensive areas in the Gabilan Valley.

*Represents specific trial conducted in each quadrant.

b. Measuring Tactical Proficiency.

(1) For each player group, the trials were rank-ordered based upon the average of the evaluators' ratings of overall unit tactical proficiency as determined from question number 2 of the TIE Test Directorate Opinion Questionnaire (table 2). This questionnaire was administered for each trial to qualified personnel within the test directorate, to include participants from the CDEC project team, CATRADA, TRADOC System Manager - Tactical Engagement Simulation (TSM-TES), ARI, the CDEC instrumentation support team, and the CDEC scientific support laboratory. In order to assure comparability of judgments among trials and between player groups, respondents were constrained, as far as practical, to have had a direct and continuous observation of the sequence of trials in the test. The average level of proficiency for each trial of each player set was computed from the respective distribution of the evaluators' ratings of tactical proficiency. To provide a hierarchy of proficiency, the trials for each player group were subsequently rank-ordered according to the average ratings. In each player set two trials had identical average ratings of proficiency, and both were assigned an average rank.

(2) An evaluator was assigned to the company headquarters, each platoon, and the TOW section of the US company/team throughout the TIE trials. These evaluators recorded a chronological listing of significant events of the trial and during player set 2 maintained a Controller Daily Performance Record (CDPR). The CDPR was designed to permit the evaluators to rate their platoon/section in particular functional areas as determined by ARTEP 71-2 on the 7-point Likert scale (same as used on the TDOQ):

<u>1 2 3 4 5 6 7</u>

Ineffective   Effective

Table 3 depicts the functional areas rated by the evaluators on the CDPR.

(a) The proficiency of player set 2 in each of the primary functional areas was determined by the average of the evaluators' ratings on the CDPR. The trials were subsequently rank-ordered according to the average ratings. These hierarchies of proficiency relating to specific functional areas were then correlated to trial sequence using the Spearman technique for correlating ranks. To identify convincing relationships between the rankings of specific proficiencies and trial sequence (i.e., learning trends for the proficiencies), the resulting correlations were examined for statistical significance at the .05 level.

(b) The average of the evaluators' ratings on the CDPR were then aggregated across all the functional areas to determine an overall rating of the tactical proficiency. These composite ratings were subsequently rank-ordered, and the resulting hierarchy of proficiency was correlated with trial sequence using the Spearman technique. As before, the correlation was examined for significance at the .05 level.

16

Table 2.
TIE Test Directorate Opinion Questionnaire
(Continued on next page)

This questionnaire is designed to elicit judgments and opinions from test directorate personnel on subjects vital to addressing the objectives and essential elements of analysis of the TIE test. Please answer the following questions, where applicable, in as great detail as you can. If a question is not applicable to you, please indicate "N/A".

Respondent _____ Parent Command _____

Date _____ Position _____

1. How does the basic level (pretest) of proficiency of this player group compare to that of the preceding player group? Please categorize your responses into those areas of unit performance that you believe best describes unit tactical proficiency.

2. What was the level of proficiency of the U.S. force during the latest trial?

Trial Date _____

Rating

____ Not Observed

_7_ Excellent

_6_ Very Good

_5_ Good

_4_ Fair

_3_ Borderline

_2_ Poor

_1_ Very Poor

3. Has the U.S. Force improved since the preceding trials?

4. Do the provisional MUTP adequately measure unit performance?

5. Can you suggest alternative MUTP which might better reflect unit performance?

Table 2   (Concluded)

6. What feedback (AAR) information is most helpful to the chain of command in correcting training deficiencies?

7. Which MUTP might be helpful to the chain-of-command in correcting training deficiencies?

8. What additional RTCA information can be collected and/or displayed (in real time) to the players in order to improve the training experience or make it more realistic?

9. What RTCA information, that is now collected and or displayed (in real time) to the players, is unnecessary or redundant?

10. Are there additional data that should be collected manually during the trial in order to provide superior feedback information to the players?

11. Can you suggest alternative methods of displaying feedback information to the players (such as plots, charts, tables) that would improve the AAR?

Table 3
CONTROLLER DAILY PERFORMANCE RECORD CHECKLIST
(Continued on next page)

1. **PREPARE FOR MOVEMENT**
   1.1 Preparation and delivery of the warning order
   1.2 Preparation and delivery of the operations order

2. **CONDUCT MOVEMENT**
   2.1 Coordinate firepower
   2.2 Locate opposing force
   2.3 Appropriate movement technique

3. **TRAVELING OVERWATCH MOVEMENT**
   3.1 Lead elements move continuously
   3.2 Lead elements use cover and concealment
   3.3 Trial elements move at various speed and stop in hull-down positions
   3.4 Trial elements key moves to terrain & overwatch
   3.5 Trial elements position for supporting firing
   3.6 Trial elements moves controlled by visual signals

4. **BOUNDING OVERWATCH MOVEMENT TECHNIQUE**
   4.1 Overwatch done from covered and concealed positions
   4.2 Overwatch position can see area of bounding element
   4.3 Overwatch fire suppressive fires on likely positions
   4.4 Overwatch position to maneuver if required
   4.5 Bounding element uses terrain to mask movement
   4.6 Bounding element uses cover and concealment at destination
   4.7 Bounding element becomes overwatch, observes front and flanks
   4.8 Movement is controlled by visual signals when possible

5. **OCCUPY OVERWATCH POSITION**
   5.1 Moves into position without exposing vehicle
   5.2 Platoon positions vehicles hull-down
   5.3 Crews observe dominating terrain
   5.4 Crews prepare to fire on likely positions
   5.5 Crews use terrain for cover and concealment
   5.6 Crews move vehicles to provide constant overwatch
   5.7 Crews observe assigned areas including air space
   5.8 Crews report any potential targets

6. **MOVEMENT FROM OVERWATCH POSITION**

7. **REACT TO CONTACT**

8. **CONDUCT HASTY ATTACK**
   8.1 Conduct hasty attack to determine strength and disposition
   8.2 Evaluate resistance and react accordingly
   8.3 Calls for immediate and planned fires

19

Table 3 (concluded)

8.4 FRAG orders are clear and complete
8.5 Maximum use of protective cover and concealment
8.6 Units support each other with max suppressive fire

9. SECURE   9.1 Dismounted attack on antitank weapons
   OBJECTIVE   9.2 Secure objective without excessive losses
                   9.3 Consolidate, reorganize, and prepare to continue

10. SUBMIT REPORTS. SECURE MEANS USED FOR LOCATION, TERRAIN AND SITUATION

11. CALL FOR   11.1 Selects proper caliber of weapons/munitions
    FIRES ON   11.2 Correct grid and OT line
    TARGETS   11.3 Correct adjustments made
    IDENTIFIED   11.4 Assists team commander in preparing fire plan

c. **Verifying Measures of Tactical Proficiency.**

(1) The evaluator ratings from the TIE Test Directorate Opinion Questionnaire (TDOQ) were analyzed to determine if there was substantial agreement among the raters in recording the level of proficiency of the US forces during each trial.

(a) The coefficient of concordance as explained by Conover (Ref 2) was proposed to test the following hypothesis (significance level =.05):

H_0: The evaluators demonstrated no consistent preference.

H_1: The evaluators demonstrated a consistent preference.

(b) In addition, the standard deviations of the evaluators' ratings as determined from the TDOQ were computed.

(2) To validate the TDOQ as an overall measure of proficiency as outlined by ARTEP tasks, the Spearman rank correlation coefficient was used to determine if there was significant agreement between the rank-order as determined by the TDOQ and that provided by the CDPR (as developed by the controllers and ARI from ARTEP 71-2). This analysis included two types of comparisons:

(a) A comparison of the overall unit proficiency as computed by the TDOQ with the overall proficiency as determined by the CDPR (significance level = .05).

H_0: The unit proficiency as determined by TDOQ is not related with unit proficiency as determined by the CDPR.

H_1: There is a correlation between the proficiency ratings.

(b) Again using Spearman correlations, the proficiency ratings of each functional area were compared to the overall proficiency rating of the unit. This comparison identified those specific areas that correlate closely to the overall unit proficiency.

d. **Detection of a Learning Curve.** If a test unit, participating in a sequence of trials, becomes more proficient, then it is expected that the latter trial ranks, in terms of tactical proficiency, would show a monotonic nondecreasing tendency. The tactical proficiency ranks were correlated with the order of trials to determine if such a trend existed.

e. <u>Statistical Testing of MOEs.</u>

(1) Computation. Those MOEs that were tractable and quantifiable were computed from automated data files or by retrieval from manual data collection forms.

(2) MOE vs tactical proficiency. Candidate MOEs that could be computed were ranked and then correlated to the rank of tactical proficiency as determined from the TDOQ. The resulting correlations were examined for two-tailed statistical significance at the .10 level. The following hypothesis applied:

H_0: MOE and tactical proficiency (TP) are not correlated.

H_1: Either

. There is a tendency for the larger values of the MOE to be paired with larger values of TP.

. There is a tendency for the smaller values of the MOE to be paired with larger values of TP.

(3) MOE vs trial replication. Those MOEs that could be computed were also ranked and then correlated to trial sequence to detect the existence of trends in the MOEs as experience was gained. *The following hypothesis applied:*

Assumption: (two-tailed test with signifance level = .10)

H_0: MOE and trial sequence (TS) are not correlated.

H_1: Either

. There is a tendency for the values of the MOE to increase with trial sequence

. There is a tendency for the values of the MOE to decrease with trial sequence

(4) Categories. MOEs were categorized under the following priorities for both tactical proficiency and trial sequence:

(a) Priority 1:

. Significant trend with tactical proficiency (or trial sequence) for player set 2 or across both player sets.

22

. Consistent trend across both player sets.

(b) Priority 2:

. Significant trend with tactical proficiency (or trial sequence) for player set 1 only.

. Significant trend with tactical proficiency (or trial sequence) for either player set with an opposite trend apparent in the other player set.

(c) Undetermined: Insufficient data were obtained during TIE to determine a reliable estimate of these MOE.

f. Cluster Analyses. To gain insights into the total MOE structure two types of cluster analyses were performed.

(1) The first procedure clustered the MOEs based on the sample correlations existing among these measures.

(2) The second clustering procedure attempted to identify similar data patterns in the variables-by-cases data matrix. This procedure provided insights into the relationship of the trial sequence and MOE structure.

g. Priority MOE. A more detailed analysis was made of selected Priority 1 MOE, as determined in 2e(4), to gain insights on how these MOE and relevant data can be presented more effectively to the unit commanders/leaders.

h. Graphic Display. The smoothed position location and event data of the second player set of TIE were displayed graphically on the Battlefield Visual Graphics System (BVGS) at CACDA. This procedure allowed a means of replaying the trials for post-trial analysis.

i. Video Display. Black and white video tapes of trials 105 through 108 were reviewed, edited, and analyzed to supplement the hardcopy data output and the graphic battle portrayals.

3. DATA ANALYSIS/RESULTS/CONCLUSIONS.

a. General. TIE was an exploratory experiment, and most of the findings provide only insights and indications as to what might be expected in subsequent NTC development. Conclusions are based largely on subjective evaluations supported where possible by objective analysis of available data. The objectives and EEAs are presented in this section with the relevant findings.

23

b. OBJECTIVE 1: Provide insights into changes in the level of unit
tactical proficiency that occur when instrumented tactical engagement
simulation is used for training.

(1) EEA 1. Was there substantial agreement among the evaluators
in rating the level of tactical proficiency of the US forces?

(a) Insufficient data were recorded to estimate the effect
between evaluators or to determine the level of agreement.

(b) Summary statistics from the frequency distributions of
the TDOQ evaluators' ratings are depicted in table 4. Since the
evaluators' ratings displayed a large variance, and since much of the
analysis on MOEs was highly dependent on these ratings, it was necessary
to be aware of these rating characteristics prior to performing analysis.

(2) EEA 2. What was the rank-ordered hierarchy of unit tactical
proficiency as determined from the evaluators' average ratings of tactical
proficiency on the TDOQ and the CDPR?

(a) For player set 2, a statistically significant correlation
established a trend between rank-orders of proficiency as determined by
TDOQ and CDPR. This relationship is depicted in figure 7.

(b) Statistical tests for trends between the ranks of overall
proficiency as derived from the TDOQ data and the rankings of proficiency
in specific functional areas indicated that the rankings of proficiency in
nine out of ten tasks were highly correlated with overall tactical
proficiency. The rankings of "movements from overwatch positions" (task
6) did not follow the trend of overall proficiency, and no data were
collected concerning "call for fires on targets identified" (task 11).

(3) EEA 3. How does the level of tactical proficiency change
after a series of instrumented engagement simulation training exercises?

(a) Table 5 depicts the hierarchy of tactical proficiency for
each player set as determined from the TDOQ data, and figure 8 represents
it graphically.

(b) Statistical tests for trends in proficiency ranking with
trial sequences, using the Spearman correlations, substantiated the
results apparent from the inspection of figure 8.

Table 4. Summary Statistics of Evaluator Ratings of
Tactical Proficiency as Recorded on TDOQ

Trial	Average Evaluator Rating	Standard Deviation	Sample Size (Number of Evaluators)
102	4.33	1.12	9
103	4.33	1.12	9
105	3.67	1.41	9
106	3.22	1.64	9
107	5.33	.87	9
108	3.75	1.28	8
109	4.22	1.20	9
110	5.25	.71	8
111	3.38	1.51	8
112	4.67	.52	6
113	3.22	1.48	9
114	3.75	1.28	8
201	3.44	1.09	16
202	3.06	1.48	16
203	3.33	1.23	15
204	3.44	1.46	16
205	4.57	1.60	14
206	4.13	.83	15
207	5.20	.77	15
208	5.60	.83	15

NOTE: Data for trials 101 and 104 were not valid due to instrumentation problems. Trials 102 and 103, while yielding data, were not included in the analysis as explained in paragraph 2a(1).

25
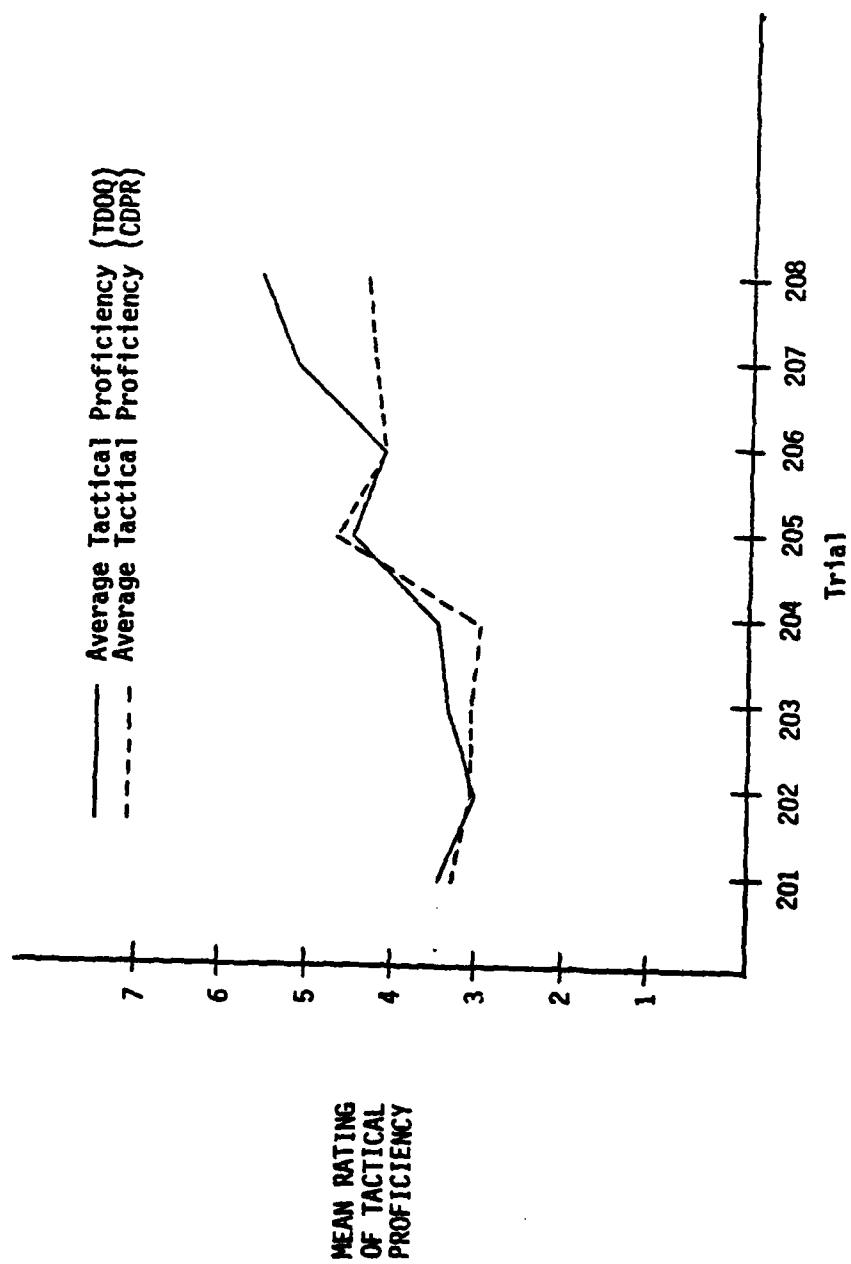
Figure 7. Comparison of average evaluator ratings of tactical proficiency for second player group as determined from TDOQ and CDPR.

26

Table 5. Proficiency Rank-Order by Trial (TDOQ)

Player Group 1			Player Group 2	
Trial	Proficiency Ranking		Trial	Proficiency Ranking
105	4		201	3.5
106	1.5		202	1
107	10		203	2
108	5		204	3.5
109	7		205	6
110	9		206	5
111	3		207	7
112	8		208	8
113	1.5			
114	6			

Player Set 1
Player Set 2

Mean Rating
of Unit
Tactical
Proficiency
(TDOQ)

Trial Sequence
(After discarding first 4 trials of player set 1)
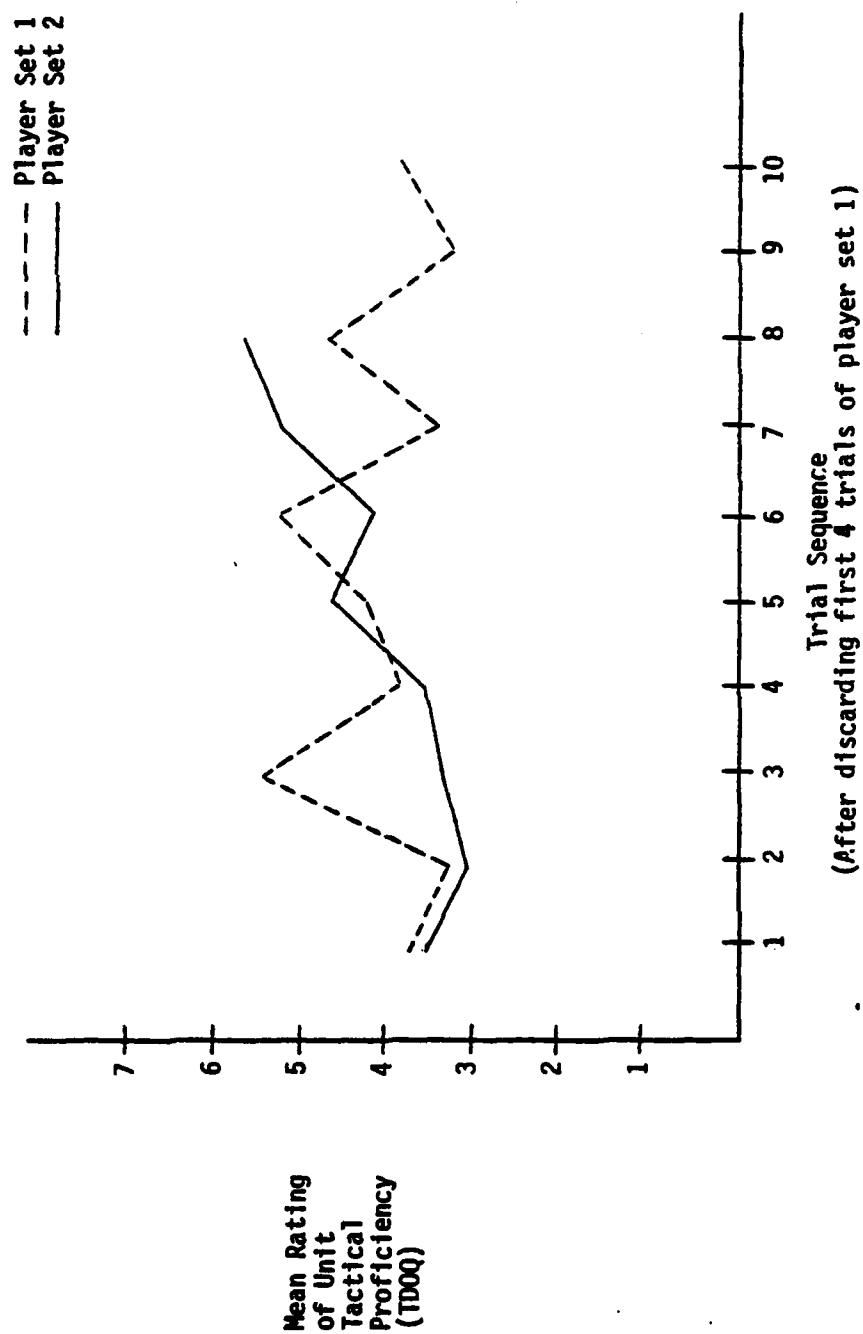
Figure 8. Average rating of tactical proficiency for both player groups as determined from TDOQ.

28

. Player Set 1: The null hypothesis stating that
there is no trend between proficiency and trial
sequence cannot be reasonably rejected.

. Player Set 2: The null hypothesis can be rejected,
with .05 signficance level, and thus the alternative
hypothesis stating that proficiency increases over
trial sequence (i.e., data indicate a learning curve)
can be accepted.

(4) Summary/Conclusions (OBJECTIVE 1).

(a) The available data indicated that there was a considerable
degree of variance among the evaluators' ratings of tactical proficiency.
Included among the factors possibly contributing to this variance are:

1. The evaluators had varying degrees of background and
experience (e.g., company grade and field grade officers, different levels of
military schooling (basic, advanced courses, CGSC), etc.).

2. The evaluators observed the trials from different
vantage points (OPs, helicopters, positions in the battle area, etc.).

(b) The average of the evaluators' ratings from the TDOQ were
shown to be consistent to the average of the evaluators' ratings from the
CDPRs both in overall proficiency and across most functional areas. This
supports the validity of using the proficiency rankings in analyzing the
MOEs. It is also indicative that the individual evaluator observations, used
to determine the ratings, were consistent with task analyses derived from the
ARTEP.

(c) It may be advantageous to establish task definitions for
future NTC tests and evaluations for the following reasons:

1. Feedback to the unit would provide specific areas of
weakness/deficiency as well as an overall rating of proficiency.

2. The unit could more readily design a training program
geared toward its specific needs.

3. Wherever possible the evaluators' subjective ratings of a
specific task could be supplemented by objective data/MOEs related to that
task. Minimum standards and criteria, developed analytically and verified by
empirical data, could be established to insure the subjective evaluations are
valid and reliable.

(d) The TIE analysis indicates that the level of tactical
proficiency for player group 2 increased during a series of instrumented
engagement simulation training exercises. The observation that this trend

29

was not apparent for player group 1 can be attributed to fluctuations in variables as described in para 2a.

c. __OBJECTIVE 2__: Verify or revise provisional measures of effectiveness (MOE). (Table 6 contains an ordered listing of the provisional MOEs.)

(1) EEA 4. What MOEs were most indicative of the ratings of unit tactical proficiency?

(a) With regard to tactical proficiency, tables 7 and 8 depict those MOEs that were categorized as priority 1 and 2, respectively (see para 2e(3)).

(b) Table 9 depicts those MOE for which insufficient data were collected during TIE to do a proper analysis.

(c) Figures 9 and 10 depict two TIE MOE that appear as fairly indicative of the average ratings of tactical proficiency. Figure 11 portrays two seemingly less meaningful MOE. However, when properly expressed as a ratio, it is precisely these two MOE that yield relative weapon survivability, one of the best indicators of the rating of tactical proficiency (figure 12). Figures 13 through 25 illustrate other ratio type MOE from the TIE test that exhibit a pronounced relationship with the average ratings of tactical proficiency.

(2) EEA 5. What MOEs were indicative of learning occurring in a particular area over trial replications?

(a) With regard to trial sequence, tables 10 and 11 depict those MOEs that were categorized as priority 1 and 2, respectively (see para 2e(3)).

(b) This analysis supported the overall subjective finding that a learning process over trial sequence in one or both of the player groups did occur. In particular, evidence of learning appeared in the following areas:

1. Terrain driving by tracked vehicles; use of cover and concealment (MOE 4.2-Player Set 1).

2. Taking advantage of protection afforded by armor vehicles (MOE 10.2 & 10.3).

Table 6. TIE MOE Index (Continued on next page).

MOE 1 (QUALITATIVE): PERCEIVED VS ACTUAL FRIENDLY SITUATION

MOE 2 (QUANTITATIVE): DISTRIBUTIONS OF ENGAGEMENT RANGES

SUB-MOE 2.1: MEAN M60 MAIN GUN ASSESSMENT RANGE
        2.2: MEAN M60 MAIN GUN TRIAL KILL RANGE
        2.3: MEAN TOW ASSESSMENT RANGE
        2.4: MEAN TOW TRIAL KILL RANGE
        2.5: MEAN US ANTITANK WEAPON ASSESSMENT RANGE (M60 MAIN GUN,
              TOW, DRAGON
        2.6: MEAN US ANTITANK WEAPON TRIAL KILL RANGE (M60 MAIN GUN,
              TOW, DRAGON)
        2.7: MEAN THREAT ANTITANK WEAPON ASSESSMENT RANGE (T62 MAIN GUN,
              SAGGER, SPG-9)
        2.8: MEAN THREAT ANTITANK WEAPON TRIAL KILL RANGE (T62 MAIN GUN,
              SAGGER, SPG-9)
        2.9: RATIO OF MEAN US ANTITANK WEAPON ASSESSMENT RANGE TO MEAN
              THREAT ANTITANK WEAPON ASSESSMENT RANGE
        2.10: RATIO OF MEAN US ANTITANK WEAPON TRIAL KILL RANGE TO MEAN
              THREAT ANTITANK WEAPON TRIAL KILL RANGE

MOE 3 (QUANTITATIVE): ESTIMATED PERCENT OF TIME SPENT IN OVERWATCH (DEFINED
                       AS THE PERCENT OF TIME SPENT STATIONARY, WHILE
                       OPERATIONAL FOR 10 MINUTES OR MORE).

SUB-MOE 3.1: ESTIMATED PERCENT M60 TIME SPENT IN OVERWATCH
        3.2: ESTIMATED PERCENT TOW TIME SPENT IN OVERWATCH

MOE 4 (QUANTITATIVE): RATE OF ADVANCE

SUB-MOE 4.1: MEAN OVERALL RATE OF ADVANCE (TO LAST PHASE LINE CROSSED)
        4.2: NUMBER OF ELEMENTS REACHING THE FINAL PHASE LINE

MOE 5 (QUANTITATIVE): AMMUNITION EXPENDITURE

SUB-MOE 5.1: NUMBER OF US ANTITANK ROUNDS (M60 MAIN, TOW, DRAGON)
              EXPENDED
        5.2: NUMBER OF THREAT ANTITANK ROUNDS (T62 MAIN, SAGGER, SPG-9)
              EXPENDED
        5.3: RATIO OF US ANTITANK ROUNDS TO THREAT ANTITANK ROUNDS
              EXPENDED

MOE 6 (QUANTITATIVE): RATIO OF TARGETS ENGAGED TO TARGETS AVAILABLE

SUB-MOE 6.1: MEAN NUMBER OF AVAILABLE TARGETS (MNAT) TO US FORCE
        6.2: RATIO OF MNAT FOR US TO MNAT FOR THREAT

31

Table 6. TIE MOE Index (Cont)

6.3: RATIO OF US ANTITANK FIRINGS (M60 MAIN, TOW, DRAGON) TO MNAT

6.4: RATIO OF US ANTITANK ASSESSMENTS TO MNAT

6.5: RATIO OF US ANTITANK TOTAL KILLS TO MNAT

6.6: MEAN TIME BETWEEN US ANTITANK FIRINGS

6.7: AVERAGE TIME BETWEEN US ANTITANK FIRINGS AT EACH SURVIVING TARGET (SUB-MOE 6.6 x MNAT) (MNAT IS DEFINED AS THE AVERAGE OVER TIME OF AVAILABLE TARGETS)

MOE 7 (QUANTITATIVE): US CASUALTIES

SUB-MOE 7.1: NUMBER OF US WEAPON SYSTEMS (M60, TOW, APC, DRAGON) TOTAL KILLED

7.2: NUMBER OF US ANTITANK WEAPON SYSTEMS (M60, TOW, APC, DRAGON) TOTAL KILLED OR SURVIVING WITH AMMO DEPLETE

7.3: CASUALTY EXCHANGE RATIO (SUB-MOE 8.1 ÷ SUB-MOE 7.1)

7.4: EFFECTIVE EXCHANGE RATIO (SUB-MOE 8.2 ÷ SUB-MOE 7.2)

MOE 8 (QUANTITATIVE): THREAT CASUALTIES

SUB-MOE 8.1: NUMBER OF THREAT ANTITANK WEAPON SYSTEMS (T62, BMP, SPG-9) TOTAL KILLED

8.2: NUMBER OF THREAT ANTITANK WEAPON SYSTEM (T62, BMP, SPG-9) TOTAL KILLED OR SURVIVING WITH AMMO DEPLETE

MOE 9 (QUANTITATIVE): NUMBER OF TARGET ENGAGED BY MORE THAN ONE US WEAPON

SUB-MOE 9.1: NUMBER OF THREAT TARGETS NOT PAIRED BY ANY US WEAPON

9.2: MEAN NUMBER OF US WEAPONS PAIRING EACH THREAT WEAPON

9.3: NUMBER OF US M60 AND TOW PAIRING AT LEAST ONE THREAT WEAPON

9.4: NUMBER OF US M60 AND TOW PAIRING AT LEAST TWO THREAT WEAPONS

MOE 10 (QUANTATIVE): PERCENT OF TIME M60 CREWS SPENT IN EACH POSTURE

SUB-MOE 10.1: PERCENT OF M60 CREWS TOTAL LIVE TIME FULLY EXPOSED

10.2: PERCENT OF M60 CREWS TOTAL LIVE TIME FULLY PROTECTED

10.3: PERCENT OF M60 CREWS LIVE TIME PARTIALLY EXPOSED (I.E., BUTTONED UP)

MOE 11 (QUANTITATIVE): AMMUNITION DEPLETE

SUB-MOE 11.1: TOTAL NUMBER OF US WEAPON SYSTEMS WITH AMMO DEPLETE

11.2: TOTAL NUMBER OF THREAT WEAPON SYSTEMS WITH AMMO DEPLETE

MOE 12.1 (QUANTITATIVE): NUMBER OF US ROUNDS FIRED BEFORE BECOMING VULNERABLE (I.E., BEFORE FIRST PAIRING BY POTENTIALLY KILLING THREAT WEAPON)

32

Table 6. TIE MOE Index (Cont)

SUB-MOE 12.1: MEAN NUMBER OF M60 MAIN GUN ROUNDS FIRED BEFORE BECOMING VULNERABLE
12.2: MEAN NUMBER OF M60 MAIN GUN ROUNDS AND SECONDARY BURSTS FIRED BEFORE BECOMING VULNERABLE
12.3: MEAN NUMBER OF TOW ROUNDS FIRED BEFORE BECOMING VULNERABLE
12.4: MEAN NUMBER OF US ANTITANK ROUNDS FIRED BEFORE BECOMING VULNERABLE (M60 MAIN GUN, TOW, DRAGON)

MOE 13 (QUANTITATIVE): NUMBER OF CASUALTIES BY INDIRECT FIRE

SUB-MOE 13.1: NUMBER OF US PERSONNEL KILLED BY INDIRECT FIRE
13.2: NUMBER OF US VEHICLES TOTAL KILLED THROUGH PERSONNEL ATTRITION BY INDIRECT FIRE
13.3: NUMBER OF INDIRECT FIRE ASSESSMENTS AGAINST US
13.4: NUMBER OF THREAT PERSONNEL KILLED BY INDIRECT FIRE
13.5: NUMBER OF THREAT VEHICLES TOTAL KILLED THROUGH PERSONNEL ATTRITION BY INDIRECT FIRE
13.6: NUMBER OF INDIRECT FIRE ASSESSMENTS AGAINST THREAT

MOE 14 (QUANTITATIVE): RANGE TO THREAT AT INITIAL CONTACT

SUB-MOE 14.1: RANGE BETWEEN CONTACTING ELEMENTS AT INITIAL CONTACT
14.2: MINIMUM RANGE BETWEEN OPPOSING ELEMENTS AT INITIAL CONTACT
14.3: MAXIMUM RANGE BETWEEN OPPOSING ELEMENTS AT INITIAL CONTACT
14.4: MEAN RANGE BETWEEN OPPOSING ELEMENTS AT INITIAL CONTACT
14.5: RANGE SPREAD AT INITIAL CONTACT (MAX-MIN)

MOE 15 (QUALITATIVE): EMPLOYMENT OF INFANTRY IN ASSAULT

MOE 16 (QUALITATIVE): MOVEMENT TECHNIQUES OF UNIT

MOE 17 (QUALITATIVE): EFFECTIVE EMPLOYMENT OF COMMUNICATIONS

MOE 18 (QUALITATIVE): PERCENT OF US FORCE HELD UP BY SPECIFIC THREAT WEAPONS

MOE 19 (QUALITATIVE): EFFECTIVE FORCE RATIOS DURING THE BATTLE

MOE 20 (QUANTITATIVE): KILLS INFLICTED BY INFANTRY

SUB-MOE 20.1: PERSONNEL KILLS BY US INFANTRY
20.2: ANTITANK WEAPON KILLS BY US INFANTRY
20.3: NUMBER OF ASSESSMENTS BY US INFANTRY
20.4: PERSONNEL KILLS BY THREAT INFANTRY
20.5: ANTITANK KILLS BY THREAT INFANTRY
20.6: NUMBER OF ASSESSMENTS BY THREAT INFANTRY

Table 6. TIE MOE Index (Concluded)

MOE 21 (QUANTITATIVE): PERCENT OF US ANTITANK FIRINGS RESULTING IN
EFFECTIVE PAIRINGS (ACCURACY OF US FIRE)
(AN EFFECTIVE PAIRING IS A WITHIN RANGE PAIRING BY A
WEAPON CAPABLE OF DESTROYING THE TARGET)

MOE 22 (QUANTITATIVE): OPFOR WEAPON CASUALTIES PER US AT ROUND FIRED

MOE 23 (QUANTITATIVE): RATIO OF US/OPFOR EFFECTIVE PAIRINGS

MOE 24 (QUANTITATIVE): PERCENT OF THREAT TARGETS PAIRED

MOE 25 (QUANTITATIVE): BATTLE INTENSITY

SUB-MOE 25.1: OPFOR PAIRINGS PER MINUTE
25.2: US PAIRINGS PER MINUTE
25.3: OPFOR WEAPONS KILLED PER MINUTE
25.4: US WEAPONS KILLED PER MINUTE

MOE 26 (QUANTITATIVE): PERCENT OPFOR FORCE EFFECTIVELY EMPLOYED (I.E.,
PAIRING AT LEAST ONE US TARGET)

MOE 27 (QUANTITATIVE): PERCENT US FORCE EFFECTIVELY EMPLOYED (I.E.,
PAIRING AT LEAST ONE OPFOR TARGET)

MOE 28 (QUANTITATIVE): EFFECTIVE (US/OPFOR) FORCE RATIO (I.E., RATIO OF US/
OPFOR WEAPON SYSTEMS THAT PAIRED AT LEAST ONE ENEMY
TARGET)

NOTE: MOEs 21 through 28 were added to the candidate MOEs (1 through 20) as a
result of this analysis.

Table 7. Priority 1 MOE (Tactical Proficiency)

MOE

3.1   Percent of time M60 spent in overwatch (1, 1&2)[a]
3.2   Percent of time TOW spent in overwatch (1, 1&2)

6.1   MNAT to US force (2, 1&2) NEG CORR[b]
6.2   Ratio (US/Threat)MNAT (1, 1&2) NEG CORR
6.3   Ratio of US firings to MNAT (2)
6.5   US AT total kills to MNAT (2, 1&2)

7.1   Number US weapon systems killed (1, 1&2) NEG CORR
7.2   Number of US weapon systems killed plus those remaining with ammo depletion (1, 1&2) NEG CORR

8.1   Number of threat weapons killed (2, 1&2)
8.2   Number of threat weapons killed plus those with ammo depletion (1&2)
7.3   Casualty exchange ratio = 8.1/7.1 (2, 1&2)
7.4   Effective exchange ratio = 8.2/7.2 (1, 1&2)

9.1   Number of threat weapons not paired by US weapon (2, 1&2) NEG CORR
9.2   Mean number of US weapons pairing each threat weapon (2, 1&2)
9.3   Number of M60 and TOW pairing at least once (1, 2, 1&2)
9.4   Number of M60 and TOW pairing at least twice (1&2)

12.1   Mean number of M60 main gun firing before being paired (2)
12.2   Mean number of M60 MG and 7.62mm firings before being paired (2)

21   Percent of Blue AT firings resulting in effective pairings (Accuracy of AT Fire) (1, 2, 1&2)

23   Blue/Red effective pairings (2, 1&2)

24   Percent of threat targets effectively paired (1, 2, 1&2)

25.1   Number of Red pairings per minute (2) NEG CORR
25.2   Number of Blue pairings per minute (1&2)
25.3   Number of Red weapons killed per minute (2, 1&2)
25.4   Number of Blue weapons killed per minute (1, 1&2) NEG CORR

27   Percent of Blue force effectively employed (2, 1&2)
28   Effective (Blue/Red) force ratio (2, 1&2)

---

a. Indicates player group(s) for which the MOE were significantly correlated with tactical proficiency ratings. 1 & 2 represents testing based on data of both player groups.
b. Indicates negative correlation between MOE and tactical proficiency ratings; all others are positively correlated.

35

Table 8. Priority 2 MOE (Tactical Proficiency)

<u>MOE</u>

14.1   Range between contacting elements at initial contact (1)*

*Indicates player group(s) for which the MOE were significantly correlated with tactical proficiency.

Table 9. Undetermined MOE (Insufficient Data)

<u>MOE</u>

2.1   Mean M60 gun assessment range
2.2   Mean M60 main gun total kill range
2.3   Mean TOW weapon system assessment range
2.4   Mean TOW weapon system kill range
2.10   Ratio of US to threat antitank weapon system mean total kill range
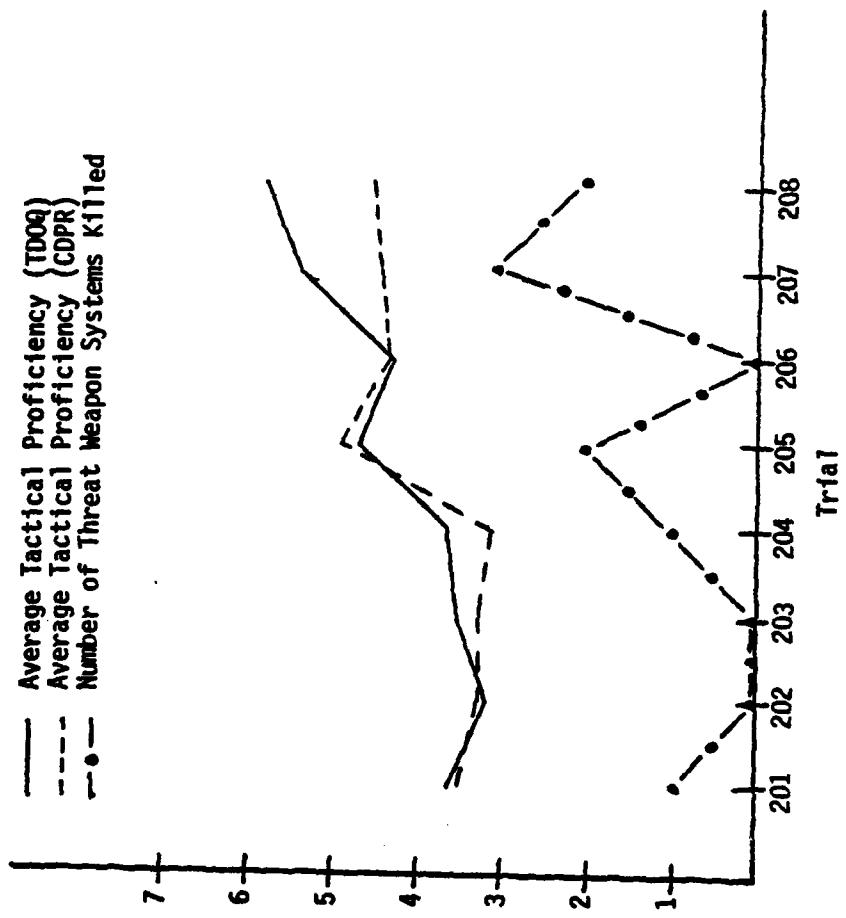
Figure 9. Number of threat weapon systems killed.

37
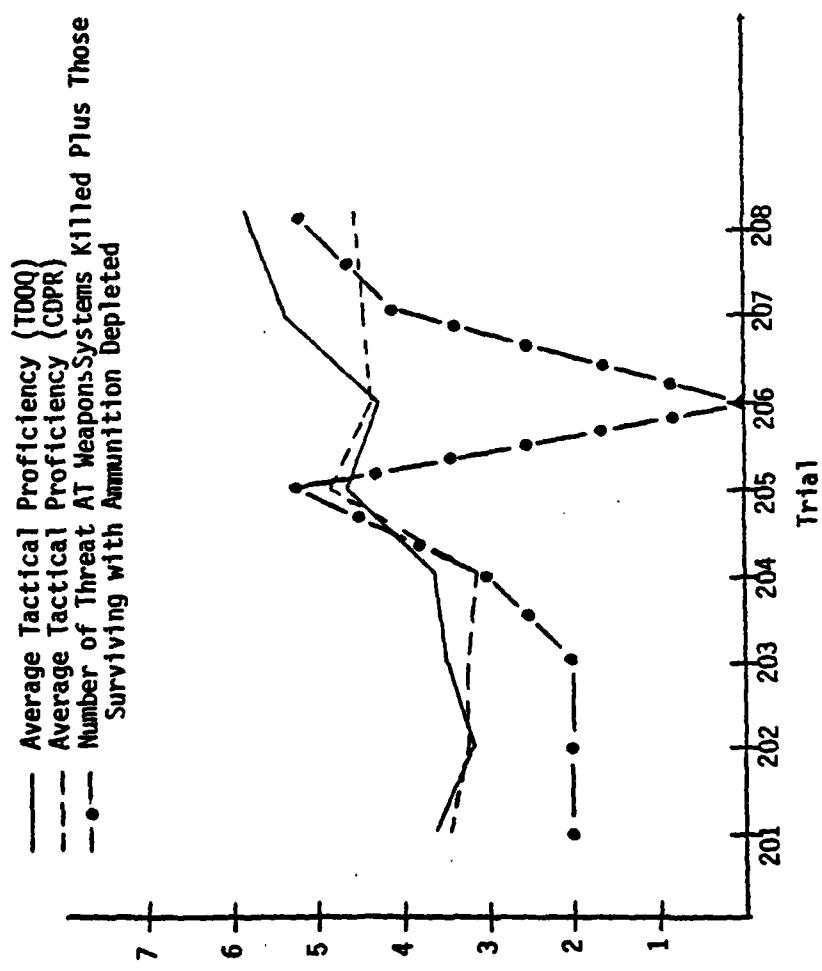
Figure 10. Number of threat AT weapon systems killed plus those surviving with ammunition depleted.

Percent of US Weapon Systems Surviving
Percent of OPFOR Weapons Systems Surviving
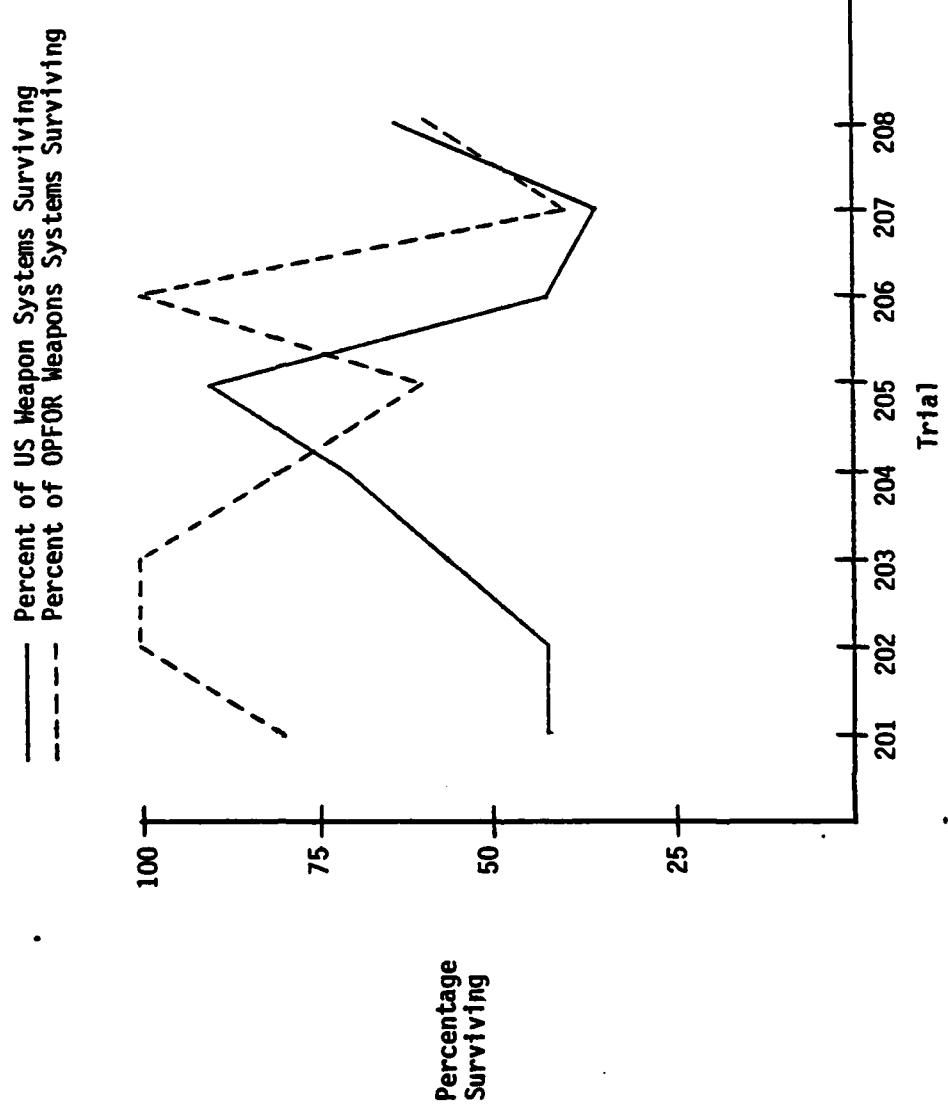
Figure 11. Percent of weapon Systems surviving.

39

Average Tactical Proficiency (TDOQ)
Average Tactical Proficiency (CDPR)
Relative (US/OPFOR) Weapon Survivability

(% US Weapons Surviving / % OPFOR Weapons Surviving)

7

.B

5

4

3

2

1

201 202 203 204 205 206 207 208

Trial
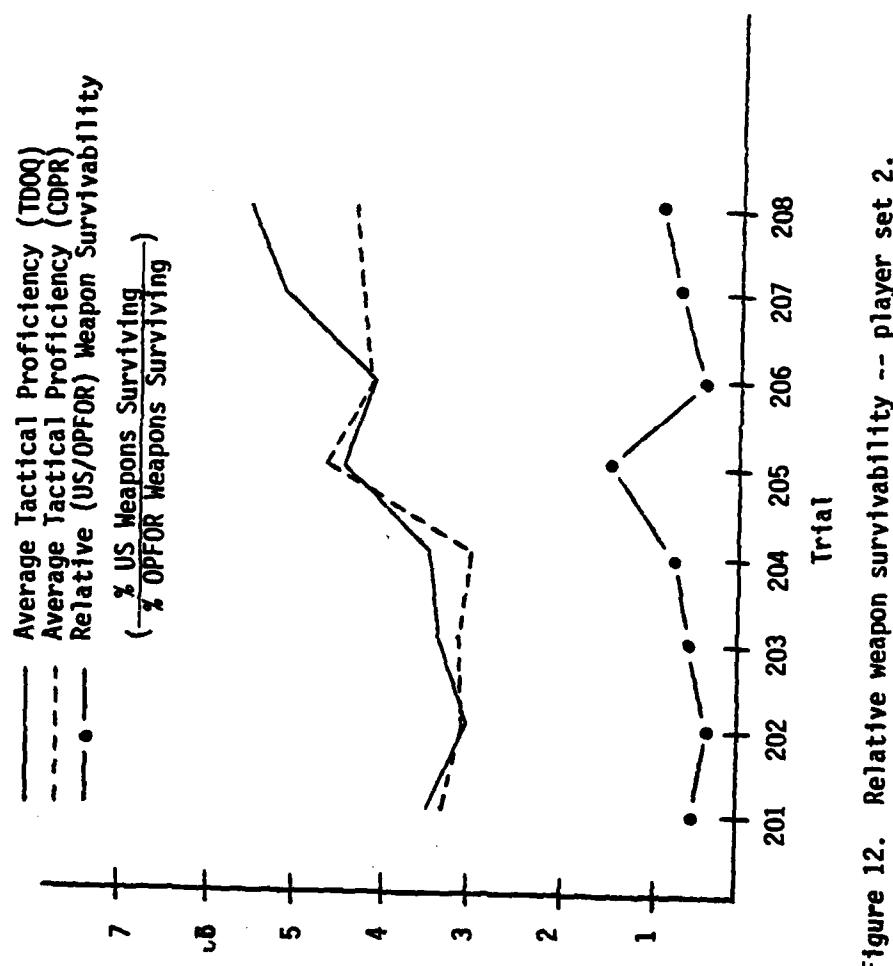
Figure 12. Relative weapon survivability -- player set 2.

40
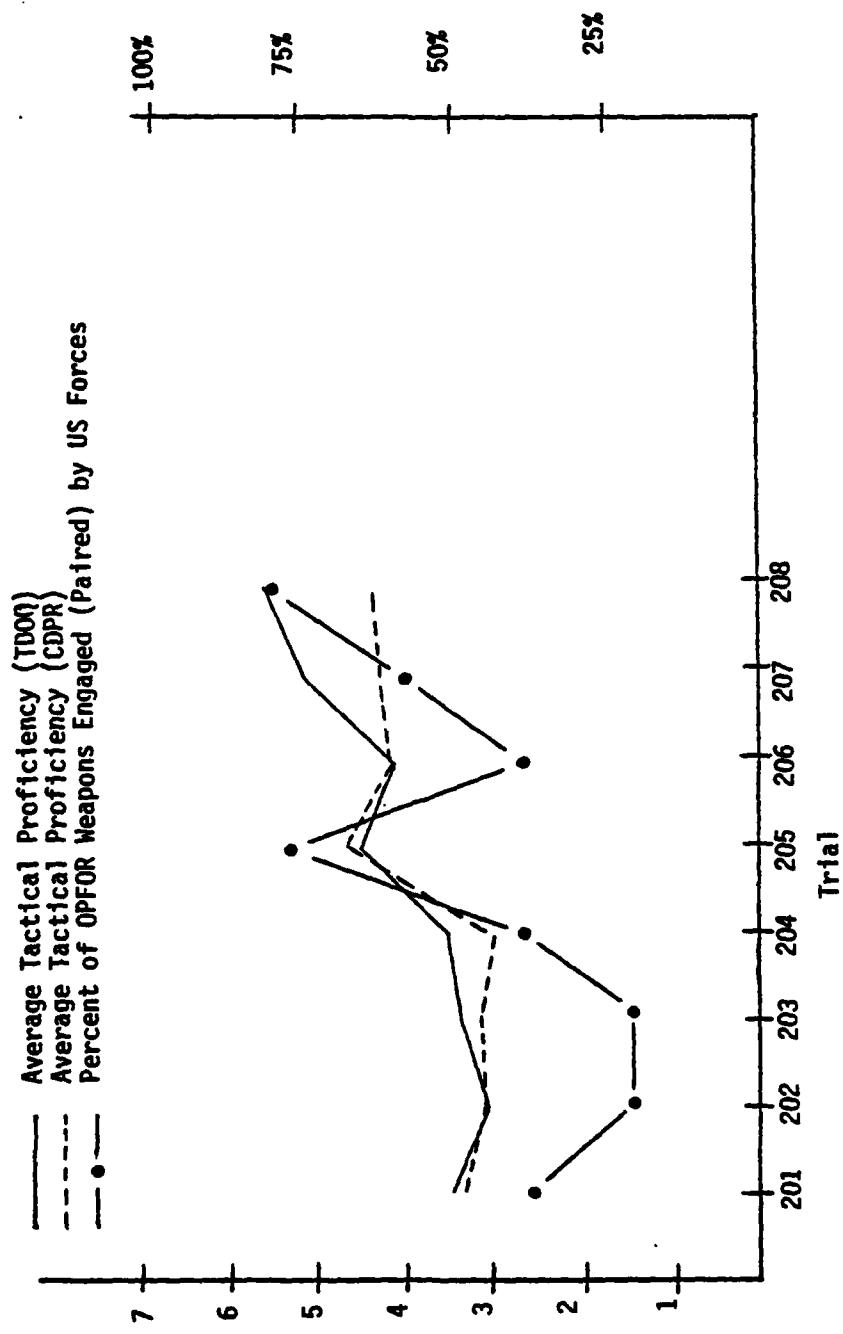
Figure 13. Locate and effectively engage (pair) OPFOR weapons -- player set 2.

41

Average Tactical Proficiency (TDOQ)
Average Tactical Proficiency (CDPR)
(US/OPFOR) Force Ratio at Start of Trial
Effective (US/OPFOR) Force Ratio*

*Includes only those weapon systems that effective.y paired
at least one enemy element.
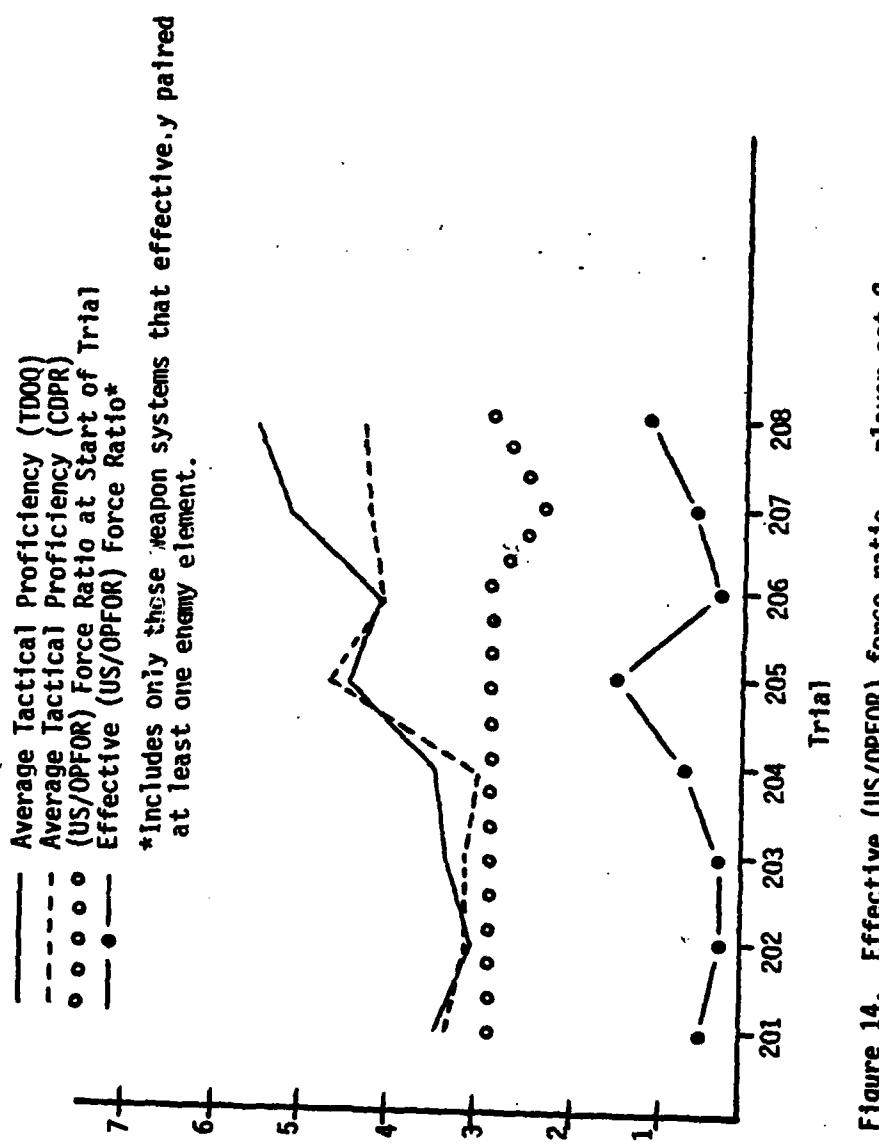
Figure 14. Effective (US/OPFOR) force ratio -- player set 2.

42
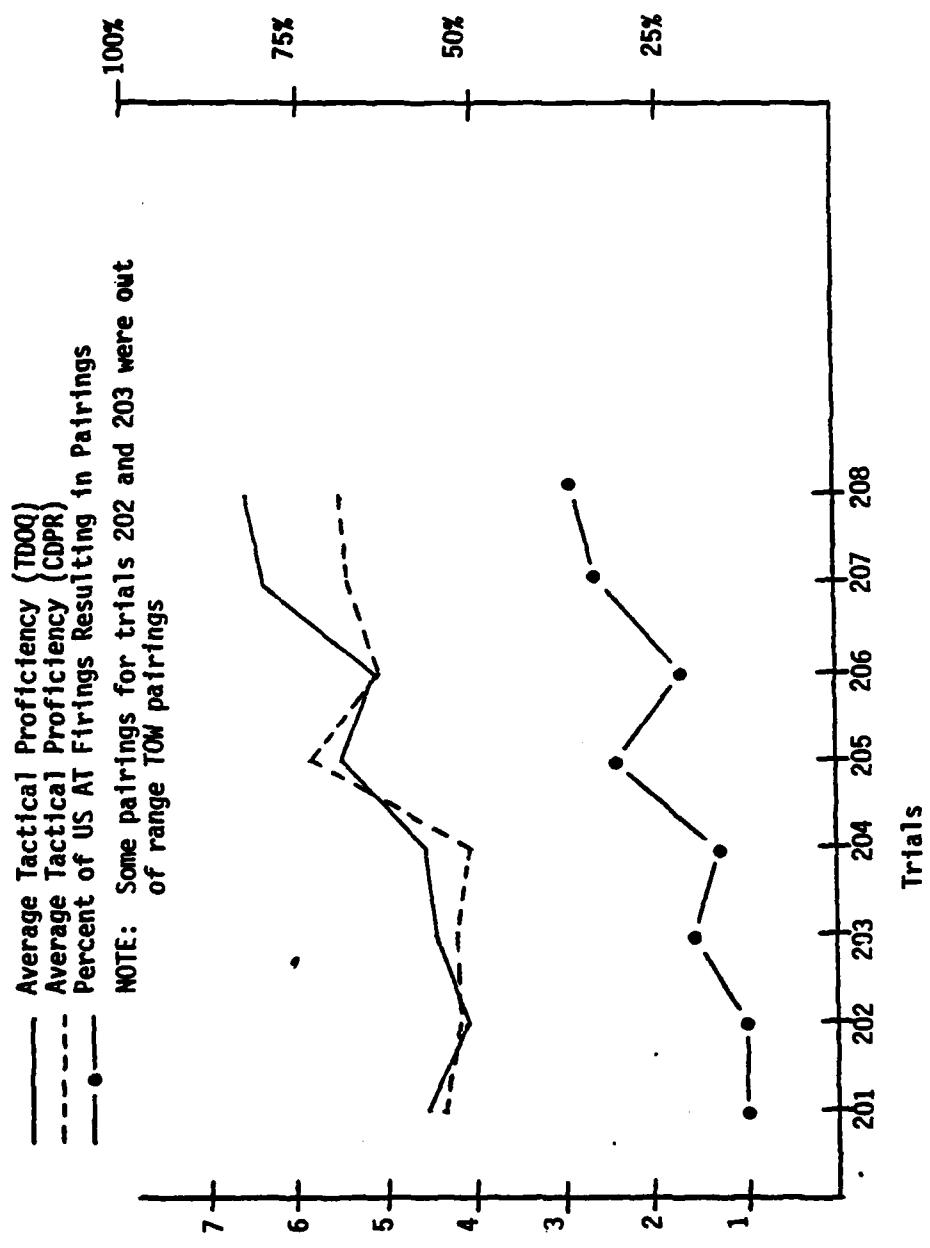
Figure 15. Percent of US antitank firings resulting in pairings -- player set 2.

43
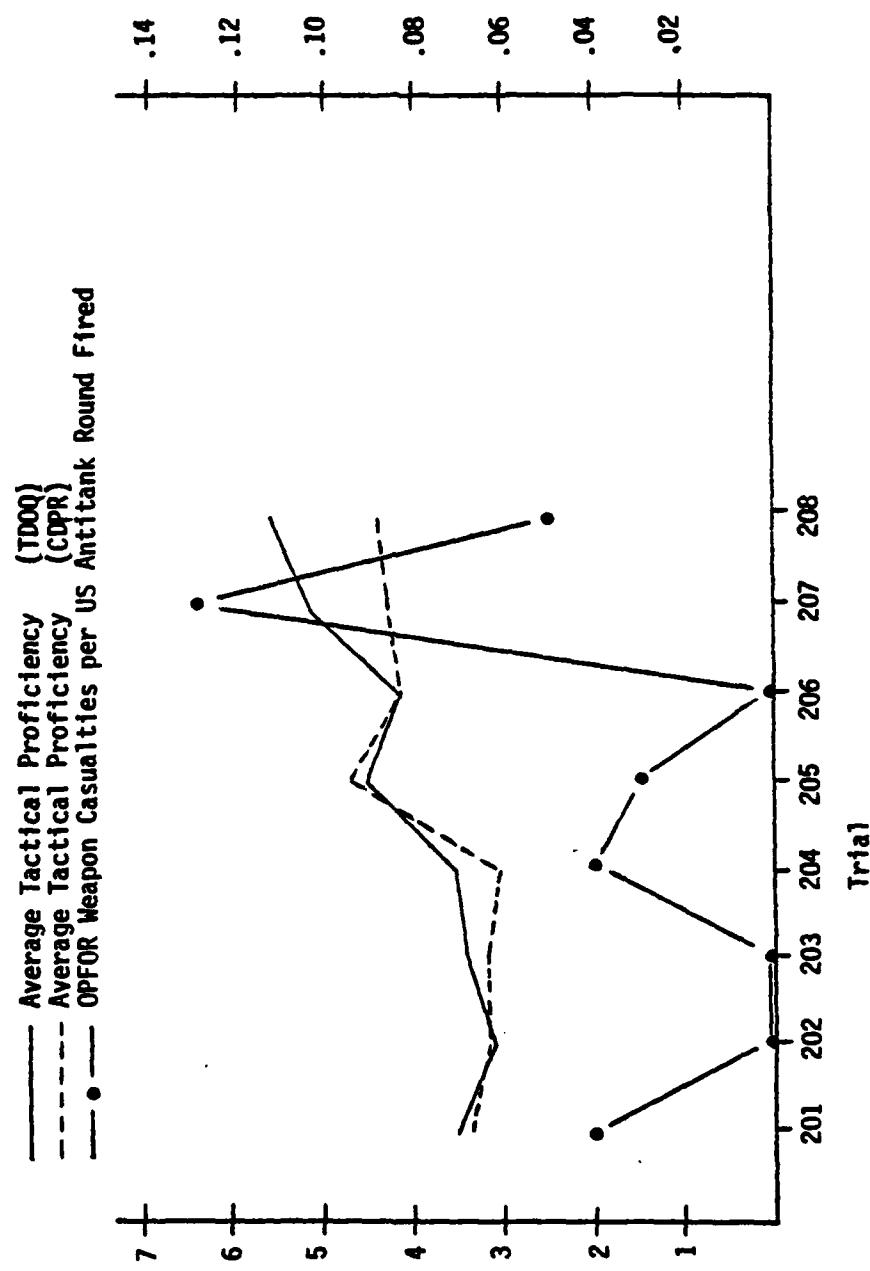
Figure 16. OPFOR weapon casualties per US AT round fired.

44
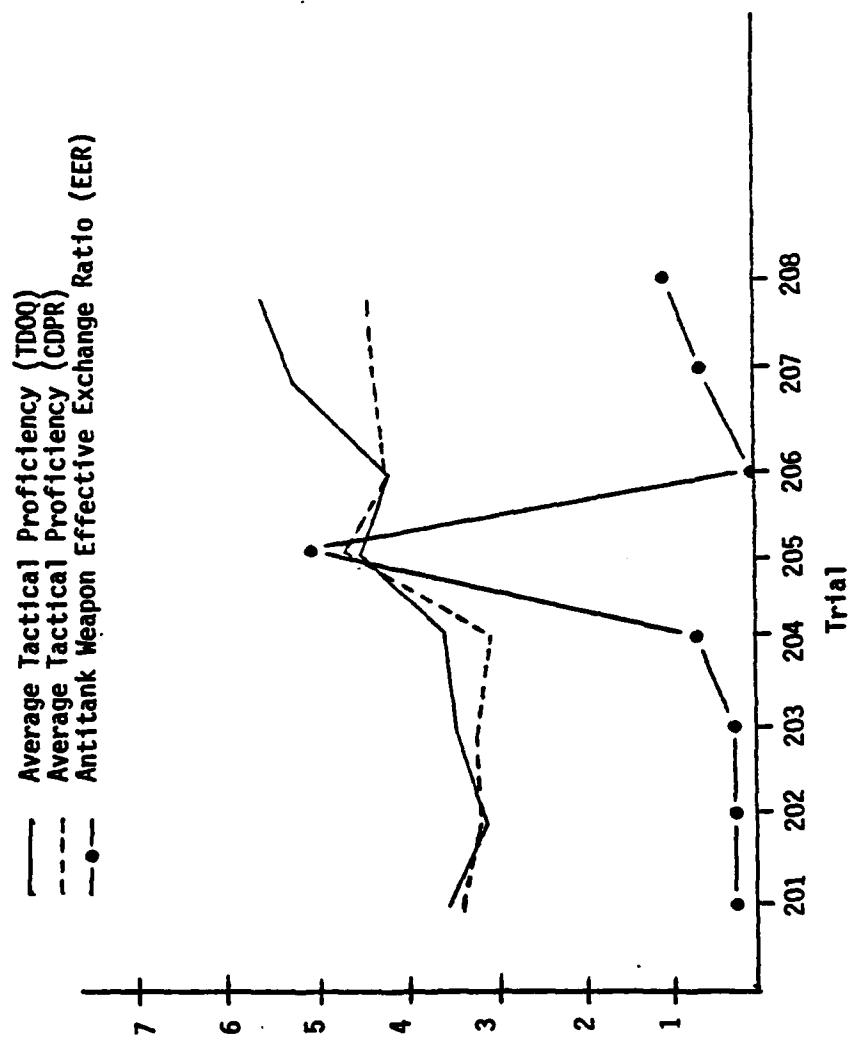
Figure 17. AT weapon effective exchange ratio (EER) -- player set 2.

45
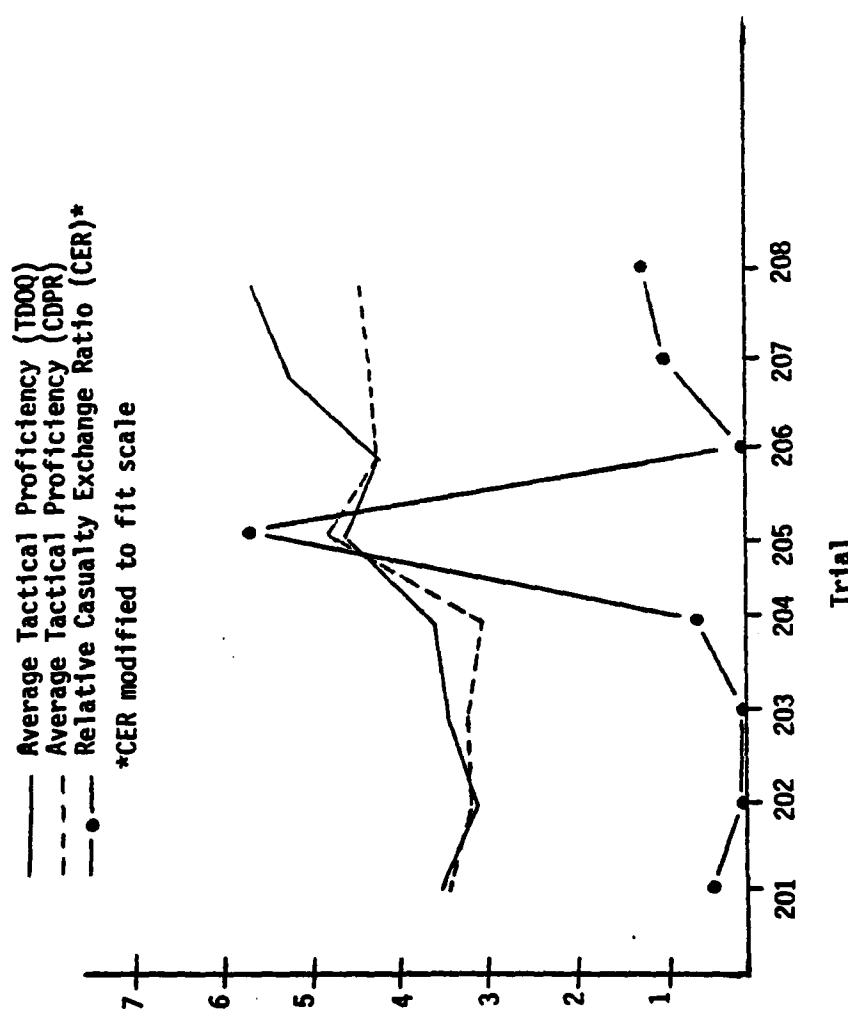
Figure 18. Relative casualty exchange ratio -- player set 2.
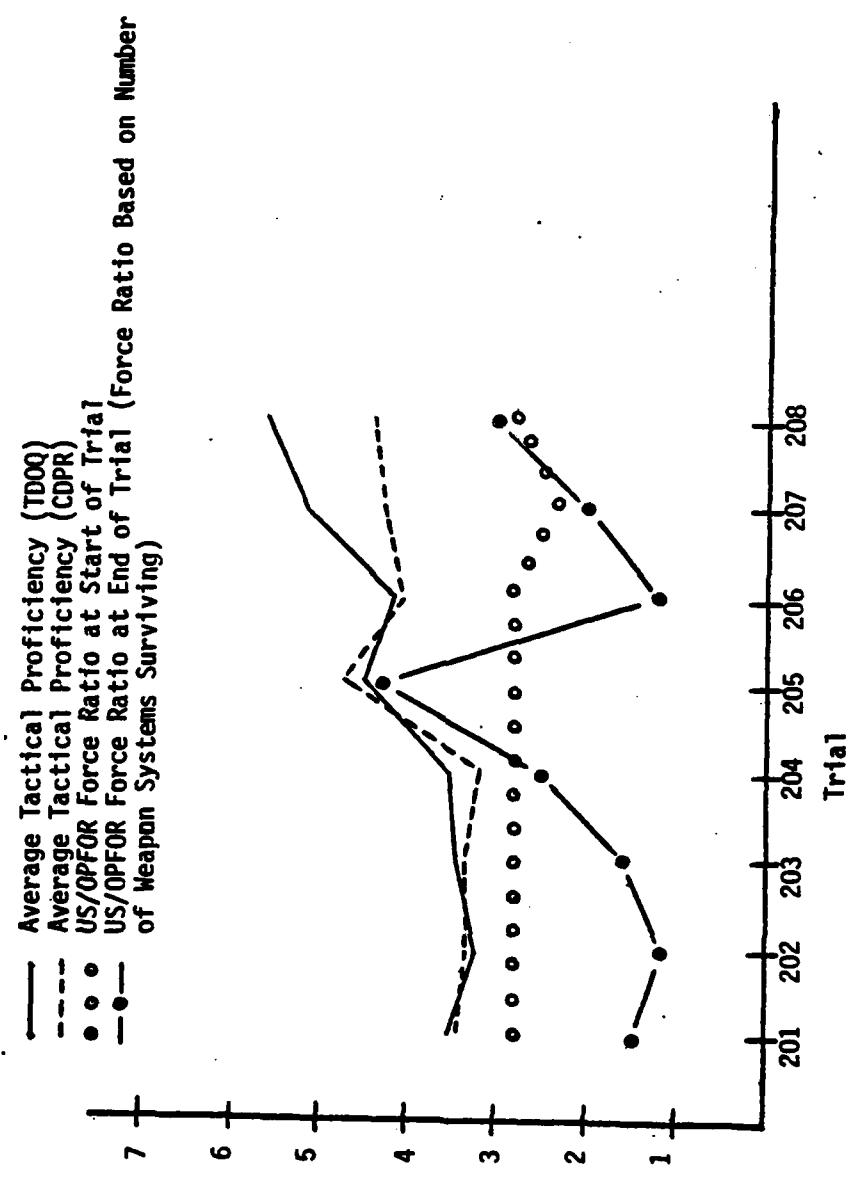
Figure 19. Force ratio at start and end of trial.

47
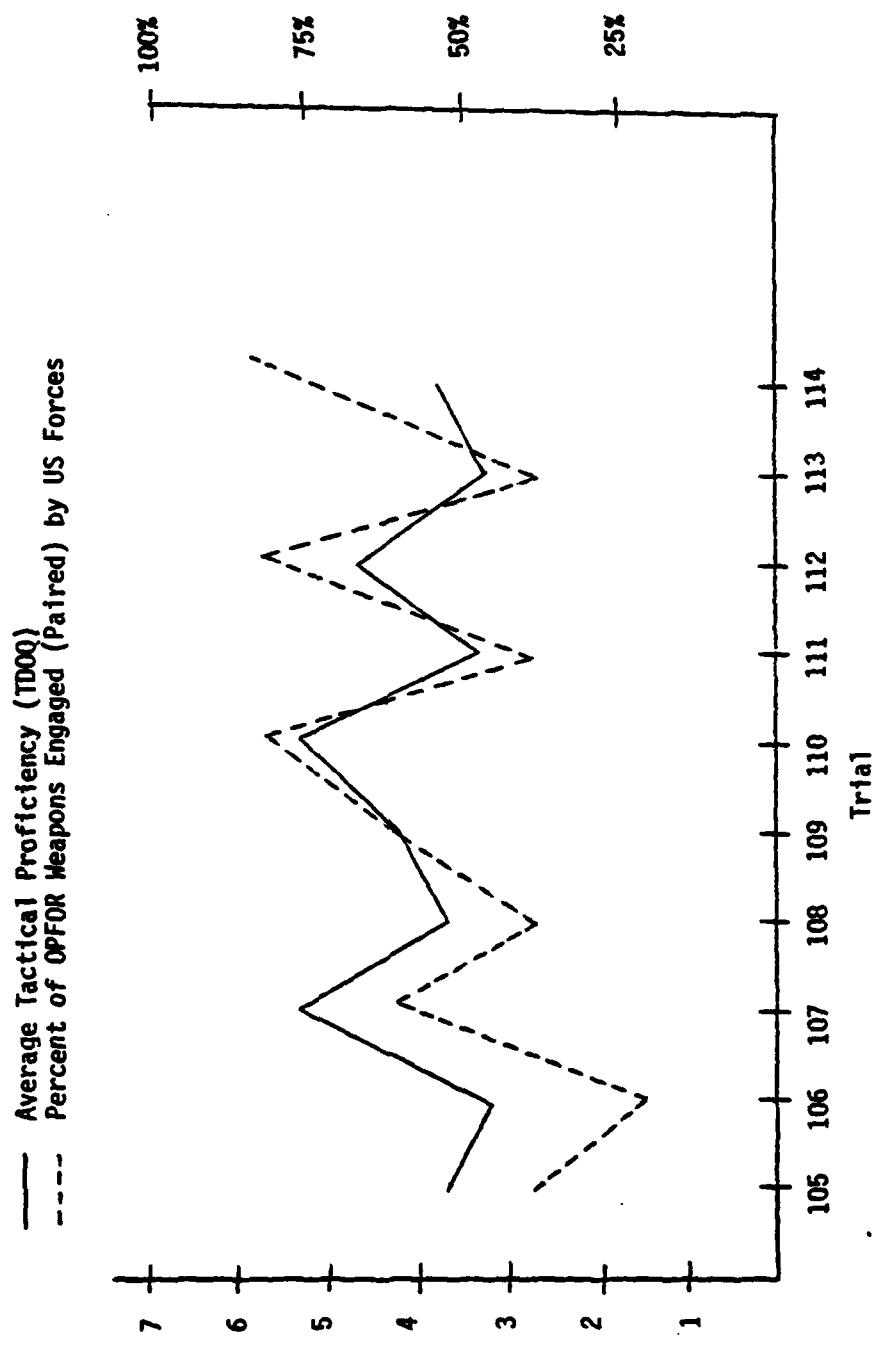
Figure 20. Locate and effectively engage (pair) OPFOR weapons -- player set 1.

48
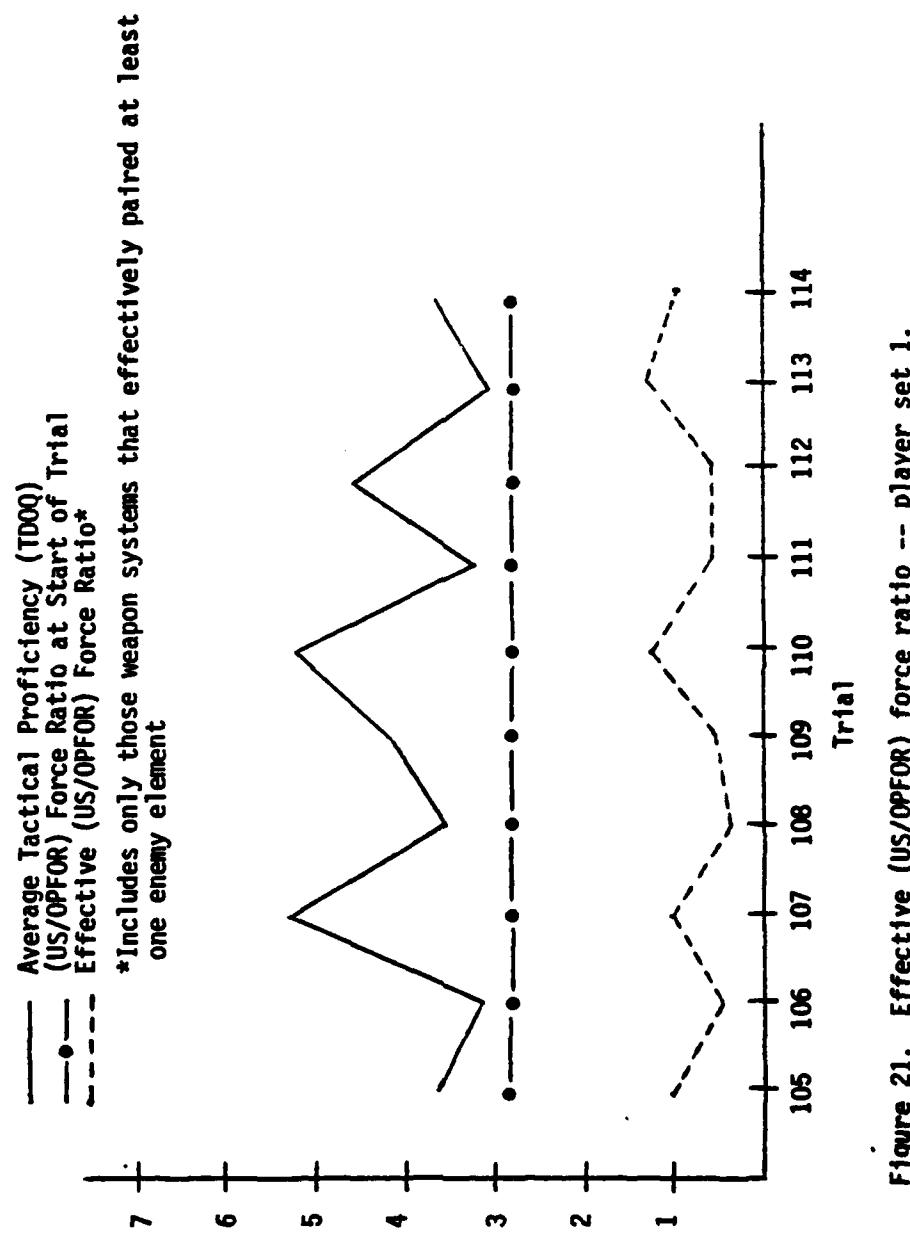
Figure 21. Effective (US/OPFOR) force ratio -- player set 1.

Legend:
- Average Tactical Proficiency (TDOQ)
- (US/OPFOR) Force Ratio at Start of Trial
- Effective (US/OPFOR) Force Ratio*

*Includes only those weapon systems that effectively paired at least one enemy element

49
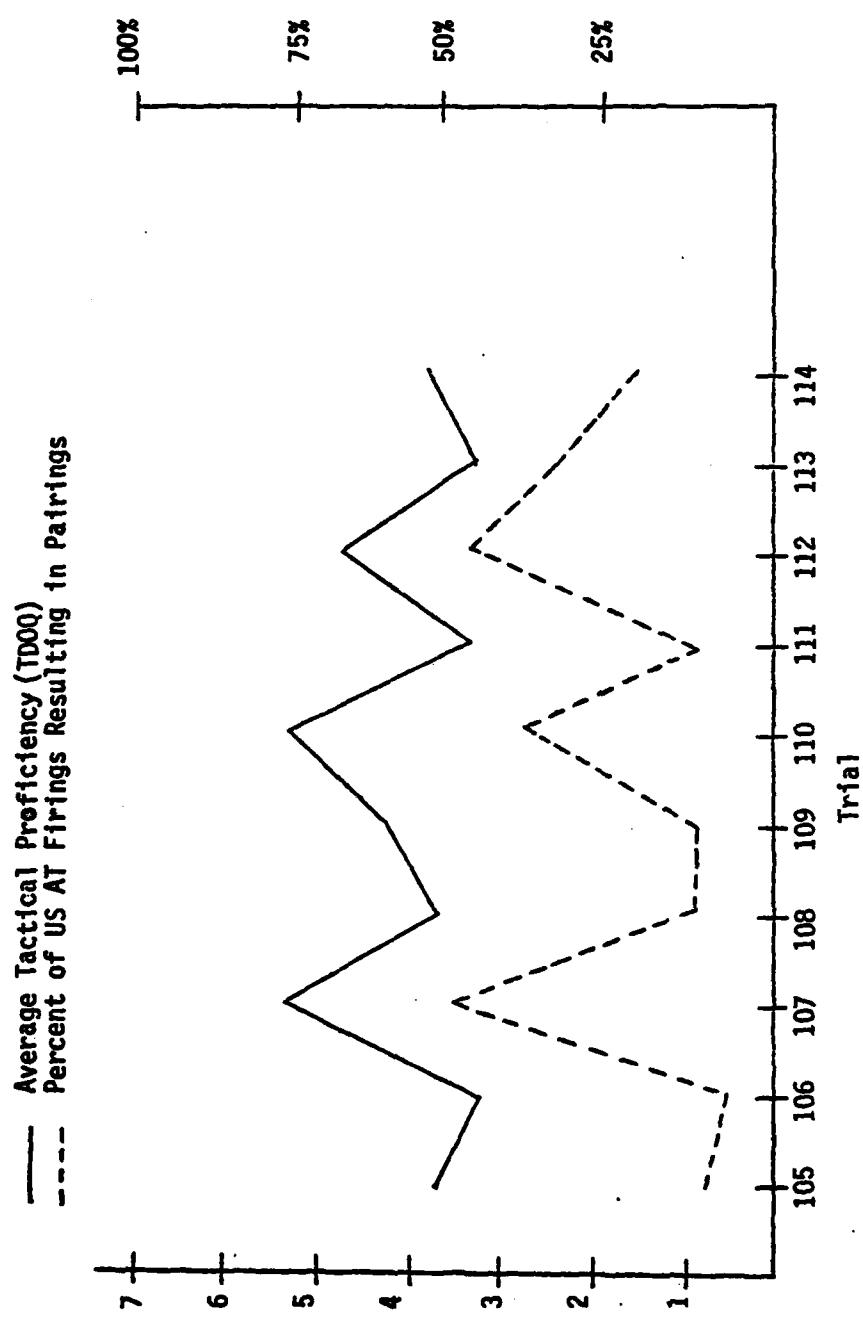
Figure 22. Percent of US AT Firings Resulting in Pairings --
Player Set 1.
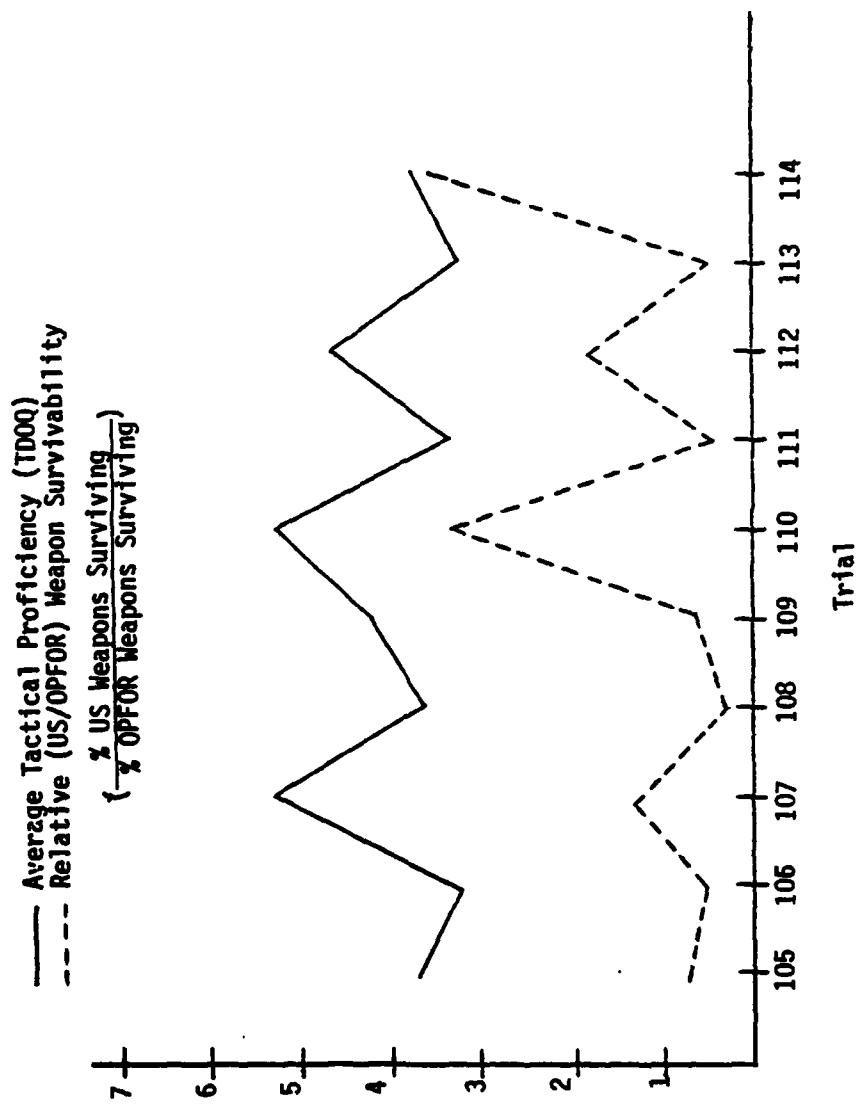
Figure 23. Relative Weapon Survivability -- Player Set 1.

51
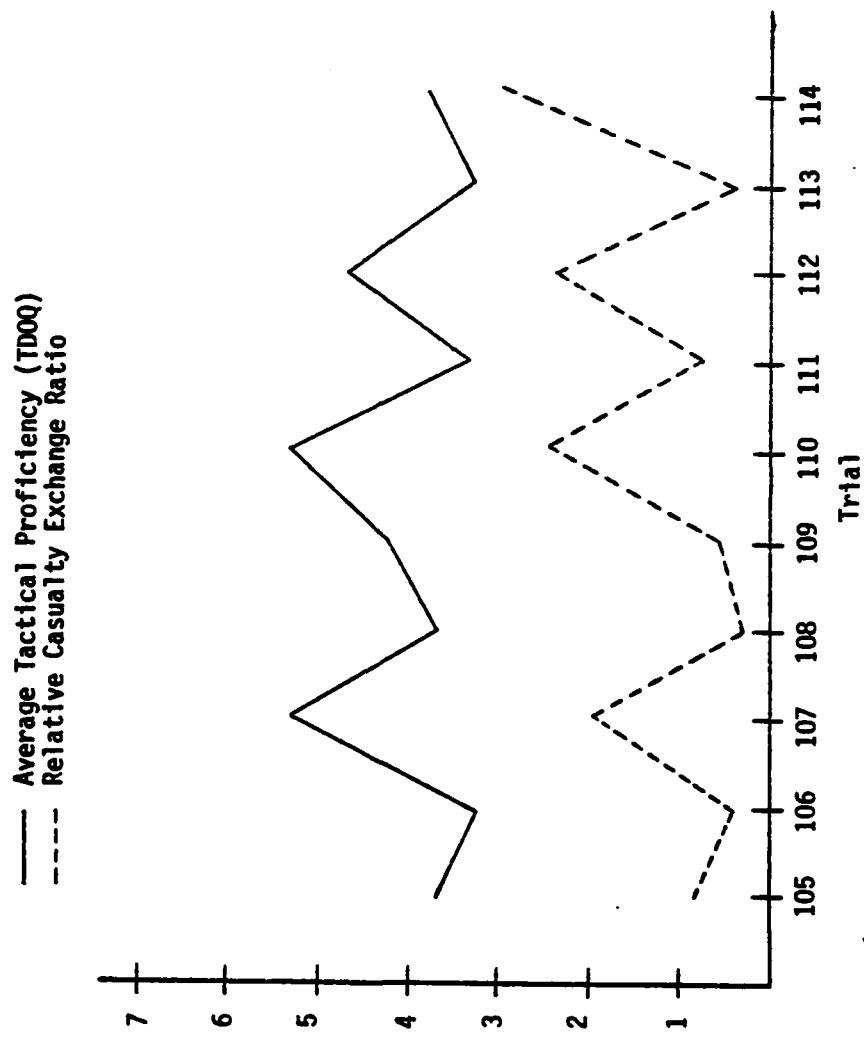
Figure 24. Relative casualty exchange ratio -- player set 1.

52
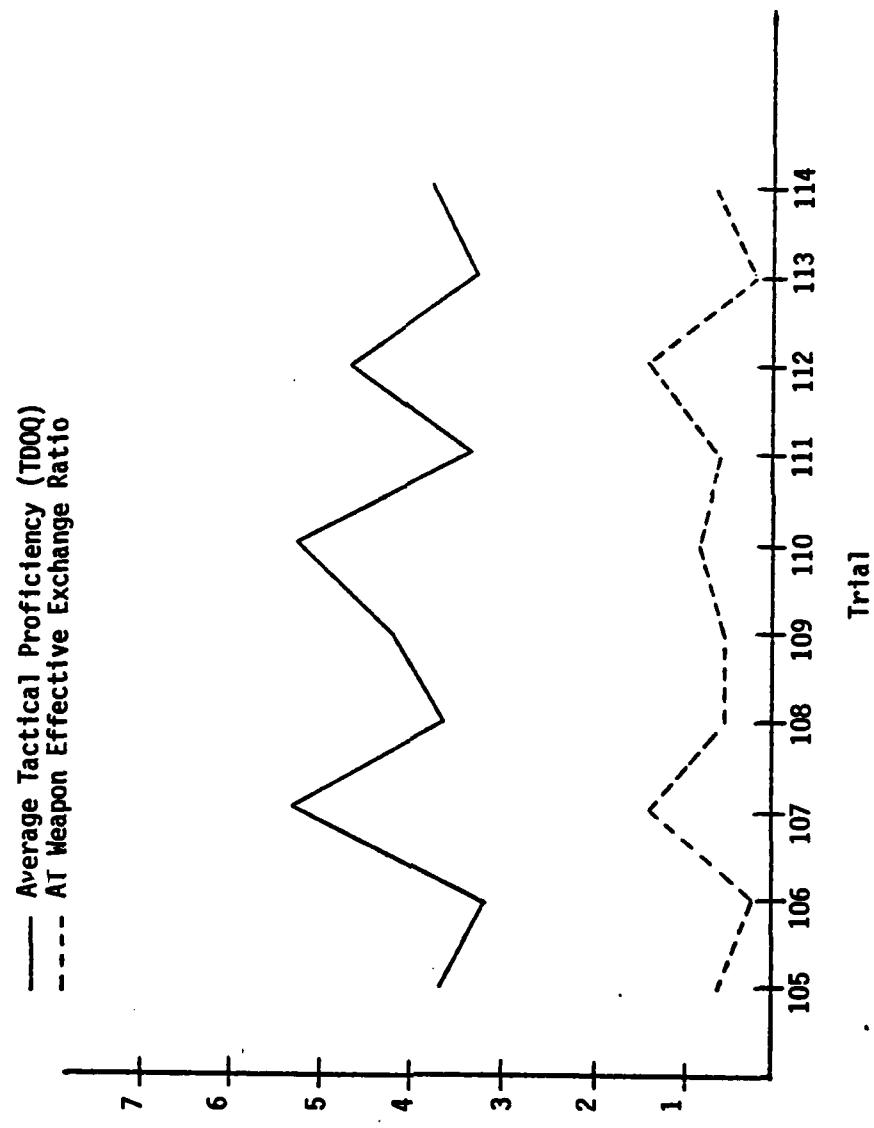
Figure 25. AT Weapon Effective Exchange Ratio -- Player Set 1.

Legend:
—— Average Tactical Proficiency (TDOQ)
---- AT Weapon Effective Exchange Ratio

X-axis: Trial (105, 106, 107, 108, 109, 110, 111, 112, 113, 114)
Y-axis: 1, 2, 3, 4, 5, 6, 7

53

Table 10. Priority 1 MOE (Trial Replication)

<u>MOE</u>

3.2   Percent of time TOW spent in overwatch (2, 1&2)[a]

8.1   Number of threat weapon systems killed (1&2)

9.1   Number of threat weapons not paired by US weapons (1, 2, 1&2)[b]
9.2   Mean number of US weapons pairing each threat (1, 1&2) NEG CORR
9.4   Number of M60 and TOW pairing at least twice (1&2)

10.2   Mean percent of time M60 crew spent fully protected (1&2)
10.3   Mean percent of time M60 crew spent partially protected (1, 1&2)

21   Percent of Blue AT fire resulting in effective pairing (2, 1&2)

23   Blue/Red effective pairings (1&2)

24   Percent of targets effectively paired (2, 1&2)

25.1   Number of Red pairings per minute (1, 2, 1&2)

27   Percent of Blue force effectively employed (1, 1&2)

28   Effective (Blue/Red) force ratio (EFR) (1 & 2)

---

a. Indicates player group(s) for which MOE were significantly correlated with trial replication. 1 & 2 represents testing based on data of both player groups.

b. Indicates negative correlation between MOE and trial replication, all others are positively correlated.

Table 11. Priority 2 MOE (Trial Replication)

<u>MOE</u>

4.2   Number of elements reaching final phase line (1)*

20.1   Number of personnel killed by US infantry (1)
20.2   Number of weapon killed by US infantry (1)
20.3   Number of assessments made by US infantry (1)

*Indicates player group(s) for which MOE were significantly correlated
with trial replication.

<u>3</u>. Target acquisition (MOE 9.1, 9.2, 9.4, 24).

<u>4</u>. Firing techniques; employment of hull defilade in firing (MOE 8.1, 9.1, 9.2, 9.4, 21, 23).

<u>5</u>. Coordinated fire and maneuver (MOE 3.2, 23, 27, 28).

<u>6</u>. Basic infantry tactics (MOE 20.1, 20.2, 20.3-Player Set 1).

(3) EEA 6. What insights can be gained concerning the validity and reliability of the MOEs as they were measured during TIE?

(a) The number of unpaired firings normally prevelant in a force-on-force instrumented trial poses a major problem in collecting sufficient data to estimate mean assessment/kill ranges for specific weapons. During TIE the mean percent of paired firings were as outlined in table 12. During TIE approximately 65 to 80 percent of the US and 20 to 50 percent of the OPFOR antitank firings were unpaired. More detailed data of percent paired firings is presented in table 13. The only actions taken on an unpaired firing were to decrement the ammunition load of the firer by one round. No data were collected on the firer's position, posture, etc. during an unpaired firing.

(b) While TIE provided insufficient data to evaluate the mean assessment/kill ranges of similar weapon systems as suitable MOE, it was apparent that aggregating such measures across weapon systems of varying designs, purposes, and effective ranges provided MOE that could be easily misconstrued.

<u>1</u>. The mean US antitank weapon assessment range for trial 201 was 1200m, computed from the following assessment data:

1 each M60 pairing at 1650m

2 each DRAGON pairings at 700m

<u>2</u>. The same MOE for trial 208 was 1250m, computed from the following data:

18 M60 pairings within 1000m

2 TOW pairings at 2700m

56

Table 12. Paired Firings Summary Statistics

	Player Group 1		Player Group 2	
	Mean % Paired	SD	Mean % Paired	SD
Blue Firings	28.6	15.5	23.25	9.3
Red Firings	69.9	13.7	64.4	24.9

Table 13. Percent paired firings.

	105	106	107	108	109	110	111	112	113	114
M60	6	0	38	14	43	26	2	50	50	8
TOW	35	57	86	0	44	75	100	40	0	67
DRAGON	NF	0	0	NF	17	0	50	NF	0	50
TOTAL	14	15	53	13	40	38	11	47	33	22

	201	202	203	204	205	206	207	208
T62	70	65	100	90	17	67	41	NF
BMP	86	63	38	88	13	67	100	75
SP69	100	100	100	100	8	100	25	83
TOTAL	78	66	74	90	12	70	45	80

NF = Not Fired

<u>3</u>. This was just one example of the inherent pitfalls in aggregating assessment range MOE across varying type weapon systems. While the collective MOE was approximately the same numeric value for trials 201 and 208, it was obvious from investigating the data by weapon type that the US force brought much more firepower to bear on the enemy at more effective ranges during trial 208.

(c) The MOE for percent of the time (M60/TOW) spent in overwatch were estimated by periods of nonmovement for 10 minutes or longer. During trails 202 and 203 both TOWs were supporting from overwatch positions that were approximately 3500m behind the maneuver element and beyond their effective range (determined from analysis of graphic display and position location data). A more valid measure of time spent in overwatch is needed for future development of the NTC. Percent time spent in overwatch could be estimated by periods of nonmovement of 10 minutes or longer, provided the weapon system was within effective range and had the necessary range fan to properly support the maneuver elements.

(d) While measures based on number of rounds fired provide a powerful diagnostic tool in determining why a unit performed as it did, they should not be used as an MOE or the units will fire indiscriminately to inflate their standing.

(e) MOE reflecting the effects of indirect fire were based solely on the number of casualties inflicted on the enemy. No means were available to record the effects of suppressive fires.

<u>1</u>. FM 71-1 "The Tank and Mechanized Infantry Company Team" emphasizes the use of indirect fires to suppress and destroy the enemy, especially in a movement to contact hasty attack scenario.

<u>2</u>. CDEC's IFCAS system, used during TIE to portray indirect fire and to determine the resulting casualty assessments, was the most sophisticated and realistic indirect fire casualty assessment and suppression system available for use in an engagement simulation exercise.

<u>3</u>. During the TIE trials the players who attempted to employ indirect artillery fire as described in FM 71-1 became increasingly frustrated with the lack of results of their indirect fires. During trials 201 through 208 an average of approximately 200 indirect fires were made per trial with one or two simulated batteries firing each mission. The cumulative casualty assessments resulting from indirect fire for the eight trials were five Red personnel and four Blue personnel casualties.

<u>4</u>. The suppression effects of indirect artillery fire could not be realistically portrayed during TIE. During trial 208 the SPG-9 was able to kill two M60 tanks within minutes of receiving approximately 50 simulated 155m artillery rounds. These simulated rounds

impacted within 25 meters of the hastily prepared defense position
(determined from analysis of graphic display and position location data).
The last three volleys were within 7 meters of the SPG-9 crew and resulted
in one casualty to the crew, but no realistic effects of suppression were
imposed on the remaining crew members.

(f) MOE reflecting the effective employment of the US
infantry indicated that infantry's contribution to the outcome of the
battle was not very significant for player group 2.

<u>1</u>. During trials 108 and 110 through 114, player set 1
was able to destroy the SPG-9 by either a mounted or a dismounted infantry
attack. After losing an average of two tanks per trial to the SPG-9 for
the first three trials, the unit commander tended to orient the deployment
of his unit solely on attacking and destroying the SPG-9.

<u>2</u>. During trials 202 and 207 the mechanized infantry
platoon led the attack, advanced too quickly, and was essentially
destroyed while out of range of mutual support from the tank platoons.
During player set 2 the DRAGON killed a BMP in trial 201 and a T62 in
trial 207. Other than DRAGON assessments and kills, the infantry did not
engage the enemy with their organic weapons.

<u>3</u>. The fact that the infantry appeared to have had a
minimal effect on the outcome of TIE trials, as measured by the number of
assessments and/or kills attributed to the infantry, might have been
driven by the following factors:

. The unit leaders, both armor captains, did not
employ their infantry assets effectively during the
course of the battle.

. The platoon leaders, both mechanized infantry and
armor, had little or no experience in conducting
combined arms operations.

. The instrumentation and procedures used during TIE
did not allow complete and effective participation
by the infantry (i.e., infantry players were
instrumented in stand-alone mode, trials were
terminated before infantry would engage in close in
combat).

60

(4) EEA7. What insights can be gained from the TIE data regarding the overall MOE structure?

(a) In an attempt to gain insights into the total MOE structure two types of cluster analysis were performed. The first procedure clustered the MOE based on the sample correlations existing among the MOEs. Because of the extremely small sample size underlying the correlations, caution must be exercised when considering the obtained results as representative. The BMDP1M computer program from the BMD biomedical statistical series (Ref 3) was used as the clustering procedure. For player set 2 the MOE clustered into three major groups: A, B, and C. Each cluster consisted of MOEs that displayed high to moderate positive correlations to the other member MOE of the cluster. In general, the MOE of cluster A were not strongly correlated with the members of either cluster B or C. However, the members of clusters B and C tended to display negative correlations to each other. Cluster membership of the various MOEs is depicted in table 14. As indicated by this table, several of the variables were transformed from their original measurement scale. This was done to reduce the skewness of the variables and thus insure better estimate of the Pearson correlations between variables. Interestingly, the rating of tactical proficiency and sequence of trial both appeared in a subgroup of cluster C and hence demonstrated a similar correlational structure to all other MOE. It should also be noted that the priority 1 MOEs tend to be concentrated in subclusters B-1, B-2, C-1, and C-2. Further interpretation of clusters and their subgroups appeared fruitless and was abandoned. Because of the aforementioned data collection problems, the correlation matrix from player set 1 was expected to be less representative than that from player set 2. For this reason no attempt was made to interpret these results in a correlational cluster analysis similar to that for player set 2.

(b) The second clustering procedure attempted to identify similar data patterns in the variables-by-cases data matrix. This procedure inquired into the sequence of trial structure as well as the structure of the MOE. Since learning was assumed to increase from trial to trial, it was hypothesized that clusters by trial sequence would occur; that is, MOE data from adjacent, or near adjacent, trials would be more similar than MOE data from nonadjacent trials. Data from neither player set 1 or 2 displayed the hypothesized trend. This would seem to indicate that: (1) the trial-to-trial variance is so great in relation to the accomplished learning that the learning effect is not identifiable, and/or (2) a majority of the MOEs are not appropriate measures of the learning occurring. To perform this analysis the BMDP3M computer program of the BMD biomedical statistical series (Ref 3) was used.

61

Table 14. Cluster Analysis for Player Set 2
(Continued next page)

Cluster A.

1)   2.1 Mean M60 main gun assessment range
      4.2 Number of elements reaching final phase line
     14.1 Range between contacting elements at initial contact
      2.5 Mean US AT weapon system assessment range

2)   2.6 Mean US AT weapon system total kill range
     14.2 Minimum range between opposing elements at initial contact
     10.1 Mean Percent of time M60 crews spent fully exposed
    *3.1 Percent of time M60 spent in overwatch

3) a)   2.7 Mean threat AT weapon assessment range
         2.8 Mean threat AT weapon kill range
        14.4 Mean range between opposing forces at initial contact

    b)   5.2 Number of threat AT rounds
       5.2.1 Number of T62 main gun rounds
        14.3 Maximum range between opposing forces at initial contact
        10.3 Mean percent of time M60 crews spent partially exposed.

*See notes at end of table.

62

Table 14. Cluster Analysis for Player Set 2
(Continued)

Cluster B.

1)   4.1 Mean overall rate of advance to last phase line
       14.5 Range spread at initial contact (Max-Min)
       *6.2 Ratio of MNAT (US) to MNAT (Threat)
       *7.1 Number of US weapon systems total killed
       *7.2 Number of US AT weapons killed or surviving with no ammo

2) a)   Transformed ratio of US to threat AT rounds
             Log 6.6 mean time between US AT firings (min)
             Log 6.7 average time between US AT firing at each
                surviving target (min)
             *Transformed 7.4 effective exchange ratio

   b) *6.1 MNAT to US forces
      *9.1 Number of threat weapons not paired
            *Transformed 7.3 CER
            *Transformed 12.1 mean number of M60 main gun firings
               before vulnerable
            Transformed 20.6 number of assessments made by threat INF
            Transformed 6.4 ratio of US AT assessments to MNAT

3)   Log 10.2 mean percent of M60 crew in fully protected
                position
       13.6 Number of IFCAS made vs threat
       13.3 Number of IFCAS made vs US forces

*See notes at end of table.

63

Table 14. Cluster Analysis for Player Set 2
(Concluded)

Cluster C.

1) 2.3   Mean TOW assessment range
    5.2.3   Number of SPG-9 rounds expected
    Log 5.1   Number of US AT rounds expected
    *Log 6.3   Ratio US AT firings to MNAT
    Log 5.1.1   Number of M60 main gun rounds expected
    Log 12.4   Mean number of US AT rounds fired before vulnerable
    *Log 9.2   Mean number of US weapons pairing each threat target
    *   9.3   Number of M60 and TOW weapons pairing at least one
                      target

2) *Log 6.5   Ratio of US AT kills to MNAT
    *   8.1   Number of threat weapons killed
    *   8.2   Number of threat AT weapons killed or surviving
                      without ammunition
    *Log 12.2   Mean number of M60 main gun and secondary burts
                      before vulnerable

3)   Rating of Tactical Proficiency
                   Trial Sequence

4) 5.1.2   Number of TOW rounds fired
    Log 12.3   Mean number of TOW rounds fired before vulnerable
    5.2.2   Number of SAGGER rounds fired
    11.2   Number of threat weapons with ammunition depleted

5) 2.9   Ratio of US/threat AT weapon assessment range
    *3.2   Percent of time TOW in overwatch

---

* Indicates priority 1 MOE with tactical proficiency.

64

(5) Summary/Conclusions (OBJECTIVE 2).

(a) The majority of data collected during TIE supported those MOE primarily related to firepower and maneuver (i.e., firing/pairing/kill events and movement rates).

(b) The learning accomplished during a sequence of force-on-force instrumented exercises is greatly obscured by the trial-to-trial variance inherent in such exercises.

(c) Those MOE depicted in tables 7 and 8 were most indicative of the tactical proficiency ratings, while those in tables 10 and 11 suggested that a learning process had occurred across trial sequences.

(d) The large number of unpaired firings during force-on-force instrumented exercises poses a significant problem in measuring mean assessment/kill ranges.

(e) MOE that require aggregation of data across varying weapon types must be used with extreme caution.

(f) A more valid measure of time spent in effective overwatch is needed for the future development of the NTC.

(g) A more realistic portrayal and valid MOE are needed for the play of indirect fire, to include the effects of suppression.

(h) The engagement simulation force-on-force training environment provides quantifiable MOE related to areas of tactical operations that have heretofore been evaluated subjectively, for example:

TACTICAL FUNCTION/SKILLS	MOE
Locate and Effectively Engage Enemy	Percent of OPFOR Weapons Paired
Maintain Mutual Support/Mass Superior Combat Power	Effective (Blue/Red) Force Ratio
Gunner Accuracy	Percent of US AT Firings Resulting in Pairings
Effectiveness of Fires	OPFOR Weapon Casualties per US AT Round Fired
Destroy Enemy While Insuring Your Unit's Survivability	Casualty Exchange Ratio; Weapon Survivability; Effective Exchange Ratio;

(i) Those MOE in (h) above are highly indicative of the tactical proficiency of a unit. These MOE are also interrelated and must be looked at in total to determine how well the unit performed and where its weaknesses lie.

(j) NTC development must include instrumentation and procedures to realistically portray the infantry in their role on the modern battlefield.

(k) TIE was the first attempt at identifing MOE related to tactical proficiency. Future testing should investigate as many MOE as is feasible, until there is a sufficient sample size to establish a valid and reliable empirical data base.

(1) Insufficient quantitative data were collected to derive command and control or intelligence type MOE, and resupply/logistics was not played.

REFERENCES

1. US Army Combat Developments Experimentation Command (1978), Training Instrumentation Evaluation (TIE) Final Report, USACDEC, Fort Ord, California.

2. Conover, W.J., Practical Nonparametric Statistics, John Wiley & Sons, Inc., 1971.

3. Dixon, W. J. (Ed), BMDP Biomedical Computer Programs, University of California Press, 1975.

APPENDIXES

A. TIE MOE Values.

B. Distribution List.

APPENDIX A: TIE MOE VALUES

Trial / MOE	105	106	107	108	109	110	111	112	113	114
MOE 2.1	1650	None	1617	50*	800	1900	None	350	650	650**
MOE 2.2	1650	None	1150	None	None	None	None	350	None	650**
MOE 2.3	1800	2050	1850	None	2250	1670	2250*	2450**	None	2050
MOE 2.4	1750	2050	1850	None	None	1483	2250**	2450**	None	2050

Player Group 1

Trial / MOE	201	202	203	204	205	206	207	208
MOE 2.1	1650*	None	None	2550**	2190	2950*	450*	500
MOE 2.2	None	None	None	None	1650**	None	450*	500
MOE 2.3	None	None	None	1583	2850*	1650*	2150.	2750**
MOE 2.4	None	None	None	2450*	None	None	2150*	2750*

Player Group 2

Legend:

2.1 — Mean M60 Main Gun Assessment Range
2.2 — Mean M60 Main Gun Total Kill Range
2.3 — Mean TOW Weapon System Assessment Range
2.4 — Mean TOW Weapon System Total Kill Range

MOE 2: DISTRIBUTION OF ENGAGEMENT RANGES (METERS)

* INDICATES SAMPLE SIZE OF 1
** INDICATES SAMPLE SIZE OF 2

Player Group 1

Trial / MOE	105	106	107	108	109	110	111	112	113	114
MOE 2.5	1770	2050	1710	50*	1090	1772	1050	1400	650	1117
MOE 2.6	1700	2050	1500	None	None	1483	2250	1400	None	1117
MOE 2.7	1859	1136	1522	1391	1417	2207	1406	720	588	778
MOE 2.8	1050	1361	1000	1394	1150	2110	1140	975	336	1175
MOE 2.9	0.95	1.80	1.12	0.36	0.77	0.80	0.75	1.94	1.16	1.44
MOE 2.10	1.62	1.51	1.50	None	None	0.70	1.97	1.44	None	0.95

Player Group 2

Trial / MOE	201	202	203	204	205	206	207	208
MOE 2.5	1200	None	None	1825	2221	2300**	1083	1250
MOE 2.6	750*	None	None	2450*	1650	None	1083	1650
MOE 2.7	1124	1106	500	2287	1100	1142	1413	743
MOE 2.8	925	1000	550	2150	None	1100	1228	910
MOE 2.9	1.07	None	None	0.80	2.02	2.61	0.77	1.68
MOE 2.10	0.81	None	None	1.14	None	None	0.88	1.81

Legend:

2.5	Mean U.S. Antitank Weapon Systems Assessment Range
2.6	Mean U.S. Antitank Weapon Systems Total Kill Range
2.7	Mean Threat Antitank Weapon Systems Assessment Range
2.8	Mean Threat Antitank Weapon Systems Total Kill Range
2.9	Ratio of U.S. and Threat Antitank Weapon Systems Mean Assessment Range
2.10	Ratio of U.S. and Threat Antitank Weapon Systems Mean Total Kill Range

MOE 2: DISTRIBUTION OF ENGAGEMENT RANTES (METERS)

*Indicates sample size of 1.
**Indicates sample size of 2.

Trial MOE	105	106	107	108	109	110	111	112	113	114
MOE 3.1	53	18	55	41	46	46	33	34	31	43
MOE 3.2	50	50	86	68	70	76	60	73	74	66

Player Group 1

Trial MOE	201	202	203	204	205	206	207	208
MOE 3.1	20	20	44	63	50	54	45	43
MOE 3.2	44	48	60	53	60	65	48	70

Player Group 1

Legend:

3.1 Percent of Time M60 Spent in Overwatch
3.2 Percent of Time TOW Spent in Overwatch.

MOE 3: ESTIMATED PERCENT OF TIME SPENT IN OVERWATCH*

*Overwatch time estimated by periods of nonmovement of 10 minutes or longer.

A-3

Player Group 1	Trial	105	106	107	108	109	110	111	112	113	114
	MOE 4.1	2.87	1.06	1.58	N/A	1.94	0.88	1.40	1.85	1.47	1.80
	MOE 4.2	1	3	8	0	3	7	9	11	4	9

Player Group 2	Trial	201	202	203	204	205	206	207	208
	MOE 4.1	2.00	N/A	2.09	1.85	1.67	1.37	2.99	1.71
	MOE 4.2	9	N/A	3	11	9	12	3	5

Legend:

N/A Not Available
4.1 Mean Overall Rate of Advance to Last Phase Line Crossed (mph)
4.2 Number of Elements Reaching Final Phase Line

MOE 4: MEAN OVERALL RATE OF ADVANCE*

* Average across all vehicle types.

Player Group 1	Trial	105	106	107	108	109	110	111	112	113	114
	MOE 5.1	71	26	17	8	38	47	57	17	15	32
	MOE 5.2	54	44	26	38	84	34	49	20	27	35
	MOE 5.3	1.31	0.59	0.65	0.21	0.45	1.38	1.16	0.85	0.71	0.91

Player Group 2	Trial	201	202	203	204	205	206	207	208
	MOE 5.1	24	24	5	23	74	9	24	38
	MOE 5.2	41	44	19	39	26	27	40	20
	MOE 5.3	0.59	0.55	0.26	0.59	2.85	0.33	0.60	1.90

Legend:

5.1   Number of U.S. Antitank Rounds Expended

5.2   Number of Threat Antitank Rounds Expended

5.3   Ratio of U.S. Antitank Rounds to Threat Antitank Rounds Expended

MOE 5: AMMUNITION EXPENDITURE

A-5

Player Group 1

Trial MOE	105	106	107	108	109	110	111	112	113	114
MOE 5.1.1	51	13	8	7	23	34	49	12	10	24
MOE 5.1.2	20	7	7	1	9	12	2	5	2	6
MOE 5.1.3	0	6	2	0	6	1	6	0	3	2
MOE 5.2.1	32	25	14	21	61	7	29	10	7	16
MOE 5.2.2	8	2	8	8	8	7	8	7	2	8
MOE 5.2.3	14	17	4	9	15	20	12	3	12	11

Player Group 2

Trial MOE	201	202	203	204	205	206	207	208
MOE 5.1.1	17	9	4	17	70	7	16	27
MOE 5.1.2	4	13	1	6	4	2	4	11
MOE 5.1.3	3	2	0	0	0	0	4	0
MOE 5.2.1	27	34	7	30	6	21	32	0
MOE 5.2.2	7	8	8	8	8	3	4	8
MOE 5.2.3	7	2	4	1	12	3	4	12

Legend:

5.1.1	Number of M60 Main Rounds Expended
5.1.2	Number of TOW Rounds Expended
5.1.3	Number of DRAGON Rounds Expended
5.2.1	Number of T62 Main Rounds Expended
5.2.2	Number of SAGGER Rounds Expended
5.2.3	Number of SPG-9 Rounds Expended

MOE 5: AMMUNITION EXPENDITURE

Trial / MOE	105	106	107	108	109	110	111	112	113	114
MOE 6.1	4.22	4.52	4.34	4.68	4.82	3.96	3.88	3.86	3.70	4.55
MOE 6.2	0.37	0.48	0.34	0.49	0.40	0.32	0.44	0.33	0.34	0.39
MOE 6.3	16.83	5.75	3.92	1.92	7.88	11.85	4.67	4.16	4.06	7.04
MOE 6.4	1.18	0.22	1.15	0.21	1.04	2.27	1.29	0.52	0.54	0.66
MOE 6.5	0.47	0.22	0.46	0.00	0.00	0.76	0.26	0.52	0.00	0.66
MOE 6.6	1.97	2.68	5.44	18.16	3.74	2.01	1.95	7.47	0.18	5.00
MOE 6.7	8.32	12.10	23.59	35.00	18.02	7.96	7.56	28.75	87.67	22.76

Player Group 1

Trial / MOE	201	202	203	204	205	206	207	208
MOE 6.1	4.87	5.00	5.00	4.80	4.31	5.00	4.13	4.26
MOE 6.2	0.53	0.48	0.40	0.36	0.32	0.40	0.49	0.33
MOE 6.3	4.93	4.80	1.00	4.79	17.76	1.80	5.81	8.92
MOE 6.4	0.41	0.00	0.00	0.83	4.87	0.40	0.73	0.70
MOE 6.5	0.21	0.00	0.00	0.21	0.46	0.00	0.73	0.47
MOE 6.6	5.58	4.09	21.20	8.20	0.83	16.67	5.83	4.26
MOE 6.7	27.17	20.45	106.0	88.50	3.58	83.35	24.08	18.15

Player Group 2

Legend:

6.1 Mean No. Available Tgts to U.S. Force (MNAT)

6.2 Ratio of MNAT (U.S.) to MNAT (Threat)

6.3 Ratio of U.S. Antitank Firings to MNAT

6.4 Ratio of U.S. Antitank Assessments to MNAT

6.5 Ratio of U.S. Antitank Total Kills to MNAT

6.6 Mean Time between U.S. Antitank Firings (Min)

6.7 Avg Time between U.S. Antitank Firings at each Surviving Target (Min)

MOE 6: RATIO OF TARGETS ENGAGED TO TARGETS AVAILABLE

Trial / MOE	105	106	107	108	109	110	111	112	113	114
MOE 7.1	8	9	3	10	8	5	10	4	9	4
MOE 7.2	8	9	1	7	8	6	8	3	7	3
MOE 8.1	2	1	2	1	1	4	2	3	1	4
MOE 8.2	4	1	4	3	3	5	4	4	1	5
MOE 7.3	0.25	0.11	0.67	0.10	0.13	0.80	0.20	0.75	0.11	1.00
MOE 7.4	0.50	0.11	1.33	0.43	0.38	0.83	0.50	1.33	0.14	1.67

Player Group 1

Trial / MOE	201	202	203	204	205	206	207	208
MOE 7.1	8	8	6	4	1	8	9	5
MOE 7.2	6	6	6	4	1	5	6	5
MOE 8.1	1	0	0	1	2	0	3	2
MOE 8.2	2	2	2	3	5	0	4	5
MOE 7.3	0.13	0.00	0.00	0.25	2.00	0.00	0.33	0.40
MOE 7.4	0.33	0.33	0.33	0.75	5.00	0.00	0.67	1.00

Player Group 2

Legend:

7.1 Number of U.S. Weapon Systems Total Killed
7.2 Number of U.S. Antitank Weapon Systems Total Killed plus Those Surviving with Ammo Depleted
8.1 Number of Threat Weapon Systems Total Killed
8.2 Number of Threat Antitank Weapon Systems Total killed plus Those Surviving with Ammo Depleted
7.3 Casualty Exchange Ratio
7.4 Effective Exchange Ratio

MOE 7 AND 8: U.S. AND THREAT CASUALTIES.

Trial / MOE	105	106	107	108	109	110	111	112	113	114
Player Group 1										
MOE 9.1	3	4	3	2	2	1	3	1	2	0
MOE 9.2	0.8	0.2	0.8	0.6	0.8	2.2	1.0	1.0	0.8	1.4
MOE 9.3	4	1	4	2	3	6	2	2.	2	3
MOE 9.4	0	0	0	0	1	3	1	1	0	1

Trial / MOE	201	202	203	204	205	206	207	208
Player Group 2								
MOE 9.1	3	4	4	3	1	3	2	1
MOE 9.2	0.4	0.2	0.2	0.6	1.4	0.4	0.6	1.0
MOE 9.3	1	1	1	3	5	2	2	4
MOE 9.4	0	0	0	0	2	0	0	1

Legend:

9.1 Number of Threat Weapons Not Paired by any U.S. Weapon

9.2 Mean Number of U.S. Weapons Pairing each Threat Weapon

9.3 Number of M60 and TOW Weapons Pairing at Least One Threat Weapon

9.4 Number of M60 and TOW Weapons Pairing at Least Two Threat Weapons.

MOE 9: NUMBER OF TARGETS ENGAGED (PAIRED) BY MORE THAN ONE U.S. WEAPON

Trial / MOE	105	106	107	108	109	110	111	112	113	114
MOE 10.1	4.06	0.93	3.49	3.61	13.81	0.00	7.54	8.96	5.17	13.35
MOE 10.2	3.17	37.73	9.43	7.01	15.36	16.50	16.82	19.40	31.08	21.69
MOE 10.3	92.77	61.34	87.08	89.38	70.83	83.50	75.64	71.64	63.75	64.95

Player Group 1

Trial / MOE	201	202	203	204	205	206	207	208
MOE 10.1	0.13	8.78	4.52	13.91	8.22	8.06	2.30	14.32
MOE 10.2	27.29	5.31	17.12	10.60	5.73	15.95	18.64	40.94
MOE 10.3	72.58	85.91	78.36	75.49	86.05	75.99	79.06	44.74

Player Group 2

Legend:

10.1 Mean Percent Time Spent in Fully Exposed Position (M60)

10.2 Mean Percent Time Spent in Fully Protected Position (M60)

10.3 Mean Percent Time Spent in Partially Exposed Position (M60)

MOE 10: PERCENT OF TIME SPENT IN EACH POSTURE (M60)

Trial / MOE	105	106	107	108	109	110	111	112	113	114
Player Group 1										
MOE 11.1	3	1	0	0	1	1	1	0	0	0
MOE 11.2	2	0	2	2	2	2	3	1	1	2

Trial / MOE	201	202	203	204	205	206	207	208
Player Group 2								
MOE 11.1	0	1	0	0	0	0	0	1
MOE 11.2	1	2	2	2	3	0	1	3

Legend:

11.1 Number of U.S. Weapon Systems with Ammunition Depleted

11.2 Number of Threat Weapon Systems with Ammunition Depleted

MOE 11: AMMUNITION DEPLETION

Trial / MOE	105	106	107	108	109	110	111	112	113	114
MOE 12.1	3.43	1.86	0.29	0.57	0.50	2.00	5.14	1.71	0.29	2.43
MOE 12.2	7.00	7.14	3.86	5.14	4.67	4.43	12.18	6.00	1.29	15.43
MOE 12.3	2.50	1.00	2.00	0.50	4.50	0.00	1.00	2.00	1.00	3.00
MOE 12.4	2.90	2.10	0.80	0.50	2.00	1.50	3.90	1.60	0.70	2.50

Player Group 1

Trial / MOE	201	202	203	204	205	206	207	208
MOE 12.1	1.71	0.29	0.57	1.00	9.71	0.43	1.50	3.71
MOE 12.2	3.86	0.29	1.71	4.57	25.00	0.43	11.00	19.00
MOE 12.3	2.00	6.50	0.50	1.50	2.00	1.00	2.00	5.50
MOE 12.4	1.60	1.70	0.50	1.00	7.20	0.50	1.88	3.70

Player Group 2

Legend:

12.1   Mean No. M60 Main Gun Rounds Fired before becoming Vulnerable

12.2   Mean No. M60 Main Gun Rounds & Secondary Bursts Fired before becoming Vulnerable

12.3   Mean No. TOW Rounds Fired before becoming Vulnerable

12.4   Mean No. U.S. Antitank Rounds Fired before becoming Vulnerable

MOE 12: NUMBER OF ROUNDS FIRED (U.S.) BEFORE BECOMING VULNERABLE*

*"Vulnerable" ≙ First Paired by Potentially Killing Threat Antitank Weapon (i.e., T62 Main Gun, SAGGER, SPG-9).

Player Group 1

Trial / MOE	105	106	107	108	109	110	111	112	113	114
MOE 13.1	0	0	1	0	0	0	0	1	0	1
MOE 13.2	0	0	0	0	0	0	0	0	0	0
MOE 13.3	0	15	12	7	0	0	0	10	0	370
MOE 13.4	0	0	0	0	0	0	0	0	0	0
MOE 13.5	0	0	0	0	0	0	0	0	0	0
MOE 13.6	14	0	8	3	1	2	14	7	0	8

Player Group 2

Trial / MOE	201	202	203	204	205	206	207	208
MOE 13.1	0	0	0	4	0	0	0	0
MOE 13.2	0	0	0	1	0	0	0	0
MOE 13.3	413	58	132	312	20	201	27	307
MOE 13.4	0	1	0	0	0	1	0	3
MOE 13.5	0	0	0	0	0	0	0	0
MOE 13.6	17	2	17	0	3	20	1	58

Legend:

13.1 Number of U.S. Personnel Killed by Indirect Fire
13.2 Number of U.S Vehicles Killed Thru Personnel Killed by Indirect Fire
13.3 Total Killed Thru Personnel Killed by Indirect Fire
13.4 Number of Indirect Fire Assessments Made vs U.S. Force
13.5 Number of Threat Personnel Killed by Indirect Fire
13.6 Number of Threat Vehicles Killed by Indirect Fire

Total Killed thru Personnel Killed by Indirect Fire
Number of Indirect Fire Assessments Made vs. Threat Force

MOE 13:   INDIRECT FIRE CASUALTY ASSESSMENT (KILLS RECEIVED)

Player Group 1

Trial MOE	105	106	107	108	109	110	111	112	113	114
MOE 14.1	1845	903	2053	2679	3807	3744	1700	1141	292	2273
MOE 14.2	1244	903	661	1793	2748	1778	688	970	292	959
MOE 14.3	4496	4170	2576	3538	4532	4256	2595	3192	4223	4048
MOE 14.4	2997	2342	1665	2780	3521	2761	1746	1993	2710	2542
MOE 14.5	3252	3267	1915	1745	1784	2478	1927	2222	3931	3089

Player Group 2

Trial MOE	201	202	203	204	205	206	207	208
MOE 14.1	2892	2914	541	3714	1998	3111	1525	1139
MOE 14.2	97	1903	539	2248	1191	1813	815	590
MOE 14.3	4545	4994	3825	4181	4120	4114	5048	3294
MOE 14.4	2215	3409	2171	3531	2595	2758	3143	2064
MOE 14.5	4448	3091	3286	1933	2929	2301	4233	2704

Legend:

14.1   Range between Contacting Elements at Initial Contact
14.2   Minimum Range between Opposing Elements at Initial Contact
14.3   Maximum Range between Opposing Elements at Initial Contact
14.4   Mean Range between Opposing Elements at Initial Contact
14.5   Range Spread at Initial Contact (Max-Min)

MOE 14:   RANGE TO THREAT AT INITIAL CONTACT (METERS)

Trial / MOE	105	106	107	108	109	110	111	112	113	114
MOE 20.1	0	0	0	1	0	0	0	0	0	0
MOE 20.2	0	0	0	1*	0	1*	1*	1**	1**	1*
MOE 20.3	0	0	1	11	0	0	2	0	7	0
MOE 20.4	0	0	0	0	0	1	0	0	1	2
MOE 20.5	0	0	0	0	0	0	0	0	0	0
MOE 20.6	0	5	0	4	0	11	16	2	8	33

Player Group 1

Trial / MOE	201	202	203	204	205	206	207	208
MOE 20.1	0	0	0	0	0	0	0	0
MOE 20.2	1D	0	0	0	0	0	1D	0
MOE 20.3	0	0	0	0	0	0	0	0
MOE 20.4	0	0	0	0	5	0	0	2
MOE 20.5	0	0	0	0	1	0	0	0
MOE 20.6	4	0	0	0	29	0	2	22

Player Group 2

Legend:

20.1 Number of Personnel Kills Inflicted by U.S. Infantry
20.2 Number of Vehicles Kills Inflicted by U.S. Infantry
20.3 Number of Assessments Made for U.S. Infantry
20.4 Number of Personnel Kills Inflicted by Threat Infantry
20.5 Number of Vehicle Kills Inflicted by Threat Infantry
20.6 Number of Assessments Made for Threat Infantry.

* Infantry Overrun of SPG-9 (Dismounted)
** Infantry Overrun of SPG-9 (Mounted in M113s)
D OPFOR Vehicle Killed by DRAGON

MOE 20: INFANTRY EFFECTIVENESS (KILLS INFLICTED)

A-15

Trial →	105	106	107	108	109	110	111	112	113	114
21 - % Blue AT Firings Resulting in Effective Pairings	10	8	47	13	13	38	11	47	33	19
22 - OPFOR Weapon Casualty Per US Antitank Round Fired	.03	.04	.12	.13	.03	.09	.04	.18	.07	.13
23 - Ratio of US/OPFOR Effective Pairings	.16	.06	.38	.04	.13	1.29	.20	.67	.38	.33
24 - % Threat Targets Paired	40	20	60	40	60	80	40	80	40	80
25.1 - OPFOR Pairings per minute	.32	.51	.26	.19	.34	.33	.27	.09	.11	.11
25.2 - US Pairings per minute	.07	.06	.11	.01	.11	.19	.05	.06	.04	.04
25.3 - OPFOR Weapons Killed per minute	.014	.014	.024	.007	.007	.043	.018	.024	.008	.025
25.4 - US Weapons killed per minute	.056	.129	.037	.074	.056	.054	.090	.031	.074	.025
26 - % OPFOR Force Effective Employed	60	80	80	100	100	80	100	100	60	80
27 - % US Force Effective Employed	21	14	21	14	21	36	21	21	36	36
28 - Effective (US/OPFOR) Force Ratio	1:1	.5:1	1:1	.4:1	.6:1	.25:1	.6:1	.6:1	1.3:1	1:1

Trial →	201	202	203	204	205	206	207	208
21 - % Blue AT Firings Resulting in Effective Pairing	13	0	0	17	31	22	29	37
22 - OPFOR Weapon Casualty Per US Antitank Round Fired	.04	0	0	.04	.03	0	.13	.05
23 - Blue/Red Effective Pairings	.10	0	0	.12	7.67	.11	.44	.88
24 - % Threat Targets Effectively Paired	40	20	20	40	80	40	80	80
25.1 - Red Pairings per minute	.24	.30	.13	.19	.02	.13	.13	.10
25.2 - Blue Pairings per minute	.02	.03	.01	.02	.15	.01	.06	.09
25.3 - Red Weapons Killed per minute	.007	0	0	.005	.013	0	.021	.012
25.4 - Blue Weapons Killed per minute	.060	.082	.057	.022	.007	.053	.064	.031
26 - % Red Force Effective Employed	100	80	80	100	60	80	80	60
27 - % Blue Force Effective Employed	14	07	07	21	36	07	23	28
28 - Effective (Blue/Red) Force Ratio	4:1	.25:1	.26:1	.6:1	1.7:1	.28:1	.75:1	1.3:1

APPENDIX B

DISTRIBUTION LIST

Organization	No. of Copies
Commander Defense Documentation Center Cameron Station Alexandria, Virginia 22314	12
Commander USATRADOC ATTN: ATCD-TM ATTN: ATTNG-PAO-NTC Fort Monroe, Virginia 23651	2 2
Commander USACDEC ATTN: ATEC-SA ATTN: ATEC-EX-TC ATTN: ATEC-PL ATTN: ATEC-PL-TL Fort Ord, California 93941	1 2 1 2
Commander USATCATA ATTN: ATCAT-TD-TO Fort Hood, Texas 76544	2
Commander USACATRADA ATTN: ATZL-TDA-AD Fort Leavenworth, Kansas 66027	4
Science Applications, Inc. ATTN: Mr. Duncan Hanson 5959 Gateway West El Paso, Texas 79925	2
Dr. Sam Parry Code 55-Py Naval Postgraduate School Monterey, California 93940	1
CPT Tim Reischl SMC 1449 Naval Postgraduate School Monterey, California 93940	1